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## 2. Preparing the dry bed

13. In the preparation of a support bed for tanks, soils corresponding to the requirements under points 7 and 8 (except macroporous soils), large, pebble-, and sand-size gravel can be used. Loamy soils can be used for the purpose, if the natural moisture content at the time of preparation amounts to 14% for the sandy loam, 22% for the loamy soil, and 24% for the pure loam.

Remarks: 1. When the base is prepared from loamy soils, the first layer of dry bed (up to the mark which guarantees drainage of water below the bottom of the tank) is to be prepared from the same type of soil.

2. Peat, mud, and plant-supporting soil may not be used to prepare the dry bed to support storage tanks.

14. When tanks are erected on macroporous soils, the dry beds under the tanks, if prepared from loamy-types soils, are laid with natural moisture (without additional materials for water drainage).

15. The beds are to be prepared in horizontal layers 15 to 20 centimeters thick, each layer being carefully compacted mechanically.

Remarks: 1. If the amount of bed material is not large, the compacting may be done by hand (stamping).

2. If 10-ton crushers, 5-ton steam rollers, or stamping plates, compressed-air or explosion-type stampers of at least 0.1 ton weight are used, the thickness of the bed can be increased to as much as 30 centimeters.

16. Only one type of bed material can be used within a single layer. If various materials are used for the bed, each layer must be of one type, and all layers must be of the same thickness as specified under point 15.

17. The surface of the bed must have a 2% slant from the middle. The diameter of the bed should be 1.4 meters, or more, larger than the diameter of the tank.

The bank at the outside of the bed should have a 1 : 1.5 slope, and should be paved. This slope value is not to be exceeded.

18. The following deviations are permitted in the preparation of the beds:

a) center of bed marker: plus 5 cm

b) slope of bed surface: plus 0.3 %

c) circumference markers: minus 5 cm between adjacent markers.

(Difference between the center markers with respect to the next point on the left and next point on the right). The markers are established with levelling instrument at no less than six points distributed over the surface of the bed.

19. The care exercised in the compacting of the bed material is to be checked. The compacting will be considered satisfactory if:

a) — in work with a light (up to 5 tons) roller-type stamping machine, the ground no longer "swells up" in front of the front roller, and the depth of the impression left by the back roller is less than five centimeters;

b) the recoil of a hand-operated tamper feels solid to the operator.

A record of the acceptance of a completed foundation bed is to be prepared in accordance with Form 1, Attachment 1.

## 3. Moisture-proof layer

20. The moisture-proof layer over the dry bed serves:

a) as a protection for the metal bottom of the tank against corrosion through ground water and condensation under the tank;

b) as a protection for macroporous, sinkable beds against soaking in the event of leaks in the bottom of the tank.

21. The moisture-proof layer is made of material with granularity corresponding to sandy loam (see Point 22), mixed with a binder (see point 23). The layer thickness is to be 80-100 millimeters, and 200 millimeters or more (depending on the degree of sinkability of the ground) for macroporous beds.

Remarks: If macroporous soils are used, an insulating layer of "black" gravel (mixture of hard gravel and bitumen) 100 millimeters thick, covered by 20 millimeters of asphalt must be provided.

22. The basic material for the moisture-insulating layer must be applied in the dry state (about 3% moisture content) only, and must have the following volume-percentage composition:

a) sand with 0.1 - 2.0 mm grain size: 60 - 80 %

b) sand, dust and powdered soil under 0.1 mm: 40 - 15 %

Remarks: 1. Loam particles under 0.005 millimeter may be contained in the basic material in amounts up to 1.5 - 5 % by volume.

2. The sand may contain gravel with grain size 2 - 20 millimeters in amounts not more than 25 % by volume.

23. Binders for the moisture-insulating layer may be: liquid bitumen according to GOST 1972-52 ("Liquid Petroleum Bitumen for Road Construction"), coal tar according to GOST 4641-49 ("Coal Tar for Road Construction"), tar oils according to GOST 783-53 ("Tar Oils"), semitar oils according to GOST 4105-48 ("Semitar Oils")/Tar Oil Blends/, as well as masut oil according to GOST 1501-57 ("Petroleum Fuels"). The binder may not contain any acids nor free sulfur. The binder is expected to be 8-10% of the total mixture by volume.

24. After the moisture-insulating mixture has been mixed, it is applied without heating in a uniform layer of the prescribed thickness and a two-percent slant from the middle to the edge. The layer may not be applied during rain or snow.

After being applied, this mositure-insulating layer is to be compacted with a roller or, if operations are hurried, with a surface vibrator or tamper.

25. The moisture-insulating layer must cover the entire surface of the dry bed and, if the tank is to be erected on macroporous soil, must additionally cover the surface of the embankment as well as an area ½ meter wide around the entire bed beyond the embankment.

26. The acceptance and approval of the moisture-inuslating layer involves:

a) the quality of the binder according to quality specifications;

b) uniformity of the applied mixture (visual inspection);

c) layer thickness according to leveling tests, thicknesses in accordance with Point 18.

d) the slant of the bed.

A record of the approval of the insulating layer must be prepared in accordance with Form 2, Attachment 1.

<u>Rigidity of the Bed Embankment and Water Drainage</u>

27. Adequate gutters, ditches, etc. must be provided to drain off surface water. The drainage gutters in the bed must have a 10-percent drop.

When tanks are erected on macroporous sinkable ground or on water-impermeable clay soils, the grading of the surface on a bench mark is not permitted. Water drainage from the embankment goes into the drainage system.





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28. When tanks are erected on the slope of a hill or mountain, they must be protected from water runoff following precipitation by a system of culverts of sufficient diameter to guarantee full runoff of water with maximum rainfall. The embankments and the bottoms of the storm culverts must be covered wibh a protective coating to prevent washouts and excess saturation.

29. For tanks containing 700 cubic meters and over, the embankments and the embankment gutters must be paved with stone before the welding work is begun or the before the tanks are tested; the necessary repaving is done after the tests are made. For tanks of this size, the bed can also be reinforced by means of a concrete ring.

If ethyl gasoline is to be stored in the tank, the bed embankments (if there is no concrete ring reinformement) are to be covered with concrete slabs or with combination slabs.

30. If the tank is erected on macroporous soils, the embankment of the bed is to be paved with stone on top the moisture-insulating layer, and the stone is to be topped with an asphalt or concrete layer at least 20 centimeters thick.

31. Once the tank has been erected and tested for leaks (filled with water), the bearing ground is to be tested for uniformity of sinkage. The level marks are to be checked at 8 places (not less than six). If the settling of the ground is not uniform, the necessary places are packed with the material prepared for the moisture-insulating layer, after the tank has been emptied (see Point 21).



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## 5. Special Procedures When Laying Tank Beds in Winter

32. As a rule, tank beds may not be laid when the air temperature is below 0°C. If the erection of a tank in winter is necessary, however, the bed must not be built at a temperature below 30°, and the conditions stated above under points 33-41 must be satisfied.

33. Laying down a tank bed in winter is permitted only if the level marks have been established before theonset of winter and the drainage system for the bed has been constructed before the onset of winter.

The erection of a tank bed on macroporous soils of the 2d and 3d settling categories is not permitted in winter.

34. The erection of a tank bed directly on frozen ground according to level marks is permitted only when the bed is laid on sandy soil or sandy clay soil.

The erection of a tank bed directly on frozen clay soil or frozen clay is permitted only when the ground water level at the site is at least one meter below the frost line.

35. A tank bed on soils which satisfy the requirements given under Point 7 (except macroporous soils) is laid in layers (with compacting according to points 15 and 19) consisting of an under layer of crushed stone or gravel 15-20 centimeters thick and an upper layer of sand.

The sand or gravel layers must have a moisture content of not more than 14 % and contain no frozen lumps.

36. The excavation and bed-laying work must be done in one continuous operation in the shortest possible time. The earth removed must be used immediately for the embankment. The laying of the bed must follow the excavation and leveling work immediately.

Remarks: All snow is to be removed from the bed area during the laying of the bed, and a tent or other shield is to be used to cover the construction area during snowfall.

37. A special moisture-insulating layer (in keeping with points 21-26) is to be applied directly on top of the dry bed.

38. The testing of the erection of the bed and the application of the insulating layer is to be done in accordance with points 18, 19, and 26.

39. When tanks are erected on macroporous or clay soils, all snow is to be removed (at all times until the end of winter) from the top of the tank and from the areas around the tank beyond the limits of the embankment.





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## II. Manufacture and Assembly of the Tanks

### 1. Materials

40. The tanks (body and bottom) which are erected in regions where the temperature goes down to minus 20 degrees C, are to be made of killed open-hearth steel III, or of better quality, M 16 or M 10 and according to GOST 380-57 with guaranteed notched-bar impact strength ofsufficient rating for minus 20 degrees; for regions with even colder temperatures, they are to be made of killed open-hearth steel M8t 3 in accordance with TekhMTU 5232-55 (Technical Specifications for Ferrous Metallurgy) with improved desoxydation or M 16 according to GOST 380-57 with additional oxidation with aluminum and notched-bar impact strength guaranteed for -40°C.

41. The roof supporting structure of the tank, the roof cover, the central supporting columns, the steps and the landings of the tank are to be made of rimmed open-hearth steel I St 3 or a better quality according to GOST 380-57.

42. The useability of the metal is to be decided by tests in accordance with the quality certificate with requirements according to GOST 380-57 or TekhMTU 5232-55, as well as by visual observation. The visual inspection involves stratifications, rolling and casting scale, tears, cracks and bumps.

If M 16 steel is used in regions having temperatures below minus 20 degrees, an additional test for notched-bar impact at minus 40 degrees must be conducted, which must be at least 3 kg/cm$^2$ under these conditions.

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Remarks: 1. Rimmed steel St 3 or a better quality according to GOST 386-57, grade 1, with guaranteed maximum carbon content, phosphorus and sulfur content according to Table 1, GOST 380-57, can be used for the body and bottom of the 700 cubic meter tanks, or smaller sizes.

2. For the supporting members of the tanks, other types of steel (carbon steels and low-alloyed steels) can be used, provided these steels satisfy welding conditions and have the notched-bar impact strength prescribed for temperatures below freezing, which are specified in Point 40 of this specification.

43. In automatic welding under powder, use may be made of welding wire (SW-08) A or Sw 08 G (A) according to GOST 2246-54 and fluxes AN-348 A, OSZ-45 (welding regulations) as well as other ceramic fluxes with analogous properties.

Manual arc welding is done with 342 A and 342 electrodes according to GOST 2523-51

44. The applicabiity of the electrodes, welding wire and flux is to be checked against data in the quality certificate with specifications according to GOST 2523-51, "Steel Electrodes for Arc- and Build-Up Welding," GOST 2246-54, "Steel Welding Wire," and according to Technical Operating Conditions for Fluxes."

Every batch of electrodes, welding wire, and flux (not over 10 tons) will additionally be inspected both visually as well as technologically according to the regulations given in Attachment 2.

The electrodes, fluxes or welding wire which do not meed technological requirements must not be used.

2. Manufacture and Aassembly of the Individual Tanks

45. The individual tank elements (caps, bottoms, sheets, or supports) are, as a rule, to be produced in a factory.

The tank bottom man, no matter what the contents of the tank, can be set up of combined sheets on the site. 700-cubic meter tanks and individual tanks for upt to 5,000 cubic meters capacity may likewise be assembled on the site , if the delivery of finished shells is not possible or desirable.

a) Requirements for Factory-Produced Tank Elements

46. Factory½produced tank parts must be made of steel in accordance with the requirements state under point 40-42. The welding quality should be in accordance with points 43 and 44.

47. The size of the rolled out tank mantle must be in accordance with design dimensions. Slight deviation in width (plus-minus 0.005 h, where h = height of the tank) and in length (pluss 50 mm) are permitted.

48. The bottom of the tank produced at the factory must not be edged, and the diameter must not be smaller than called for in the design.

49. At the factory, the sheet-metal shells are welded together by the Ellira method on automatic welding machines. Butt welds are made from both sides. The overlap welds are continuous on the outside and tack-welded on the inside. The handwelding and the tack-welding with automatic machines are to be done with E-42-A electrodes. Electrodes E-42 can be used, if the assembly work is done under favorable weather conditions (above $0^{\circ}C$).

50. The welds of the top, bottom, and shell of the tank are to be tested for leaks with petroleum or with a vacuum device. All crossover points of the vertical and horizontal welded seams of the 1st and 2d zone, and 50 percent of the crossover points of the 2d and 3d zone, and all butt-welds along the edge of the bottom are (for 2,000-5,000-$m^3$ tanks) to be tested with a light or with a magnetometer and recorder. The test results must comply with Point 99.

51. All defective welds must be erased and redone with E-42-A electrodes, either by hand or with automatic machines.

52. After being wound, the sheet-metal rolls must not be more than 3,200 millimeters in diameter. The rolls must be wound on special forms (such as the stairway scaffold) so that they will maintain their correct shape and compactness. Before being unwound, the rolls must be checked against a spiral line; this must also be done before individual windings are moved.

The entire surface of the jacket of the tank, before being unwound, must be painted with undercoating, except at places where welds have already been made or are to be made during assembly.

53. The sheet-metal sections which make up the top of the tank are to be welded together automatically or manually by the Ellira method with 342 electrodes.

The sheet-metal sections which make up thetop of the tank are to be tested by the manufacturer for leaks (petroleum or vacuum tests).

54. Finished metal parts are to be marked with paint which will not wash off,or with built-up welds, according to the numbers in the woking drawings.

55. A record of the technical acceptance according to Attachment 3 of these technical specifications must be made for each tank increased in size delivered by the factory and forwarded to the assembly plant.

56. The shipping of sheet-metal rolls and other tank parts on railroad flatcars is to be done by the manufacturing enterprise in accordance with the regulations of the Ministry of Transportation.

b) Tank Assembly from Factory-Produced Structural Components

57. The assembly plant is responsible for unloading the material from the flatcars; it will be done wihh cranes or by rolling off the cars, with guaranteed safety against damage.

58. The tank components are to be shipped from the unloading point to the point of erection with multi-wheel flat-body trailers or on tractor-(sled)-trailers.

59. The tanks are to be erected directly on the prepared dry bed with its coating of insulating material. Care should be exercised in unrolling the sheet-metal so as not to damage the insulating layer.

60. The setting up and unrolling of the shell roll is done on the tank bottom after the tack welds have been completed, with care being exercised to see that no disforming of the bottom edge of the shell (tank body) takes place.

61. The tank body is to be set up in such a way that:

a) the vertical welds are not over the input and output taps;

b) the welds of the framework are at least 500 millimeters apart and 500 millimeters from the vertical welded seams of the tank body;

c) one sheet of the tank body does not contain more than four cut-outs for the connection or admission of accessories; exceptions to this rule are the cut-outs for the tank-heating pipes and for small taps; the heating pipes and small taps are to be cut through those sheets which have no other openings (not in sheets which contain the feed and circulation pipes); one sheet can contain up to 8 feed pipes of 100 millimeters diameter each.

62. During assembly and erection of the tank shell, top sections should be attached, or (temporary?) ties attached, to make sure the shell will remain standing. If the attachement of the top of the tank and the unrolling of the shell are not to be done simultaneously, the tank shell must be supported in such a way that the wind will not blow it over. Generally, the shell is unwound within one working day. If the top cannot be set on in the same day, the shell should not be left standing without rigid supports.

63. The last vertical joint of the tank shell is a lap joint of at least 40 mm.

64. The erection of the supporting structures of the tank cover is to be done in accordance with the regulations in TU-110-55 (Technical Specifications for the Execution and Acceptance of Construction and Assembly Operations, Manufacture and Mounting of Steel Structures).

65. The top covering of tanks with inside pressures over 20 millimeters (water) is to be attached to the supporting members of the roof by electro-riveting or any type of welding which will guarantee a good joint and a good seal for the top.

66. The tanks may be welded only after the quality of the completed assembly work has been checked and preparations for welding have been made. The test includes a check on the preparation stated in Point 76, on the correct gap spaces according to Point 77 and the cleaning of the welding surfaces of dirt, moisture, rust, etc.

67. Welding at the most important places (vertical lap welds at theshell, butt welds at the edge of the bottom, seams where the shell is attached to the bottom, and seams at the manholes and piping in the lower section) is to be done only by qualified welders who have passed the test and received appropriate diplomas in accordance with "Testing for Arc- and Gas-Welders" of the State Technical Bureau of Mining Inspection, dated 27 June 1955. (6th Category welders)

The remaining welding work is to be done by welders of at least the 5th Category, with appropriate diplomas. Before beginning the welding work, the welders must concurr in the requirements stated in Attachment 4.

68. The most important welds in the assembly work on the tanks (see Point 67) are to be made with manual arc-welding methods using E-42-A electrodes or with automatic welding machines with the welding-under-powder method. The rest of the weldments may be produced with E-42 electrodes.

69. The welded joints between the jacket of the tank and the bottom, in the case of tanks with a capacity of 2,000 cubic meters and over, are to be done in two layers on both sides by the step-back welding method. The inside and outside seams are, as a rule, to be done simultaneous with the inner seam somewhat ahead of the outer. If they are to be done at different times, the inner seam must be done first. For tanks under 2,000 cubic meters'capacity, the shell-to-bottom joints are likewise done on both sides, but can be done in a single layer.

The last vertical welds of the shell (lap-welds) are to be done on both sides by the step-back welding method.

70. The welded seams must be marked within a distance of 30-40 millimeters by the identification number of the welder, either by built-up welding or by stamping.

71. The accessories which fit into the openings in the first course of sheet must be attached before the hydraulic tests are conducted.

c) Special Precautions in the Manufacture and Assembly of Tanks from Sheet Metal

72. The sheet must be cleaned of dirt, scale and rust; buckles must be straightened out.

73. The sheets used to make tanks are to have a precise rectangular form.

Deviations in length and width of plus-minus two millimeters for butt welds and plus 20 - 5 mm for lap welds are permitted. For sheets joined by butt welds, the difference in the long diagonal direction can be up to three millimeters, and up to six millimeters for the lap joints.

74. When tracing is used (scribing), a standard metal measuring instrument which guarantees the desired tolerances must be employed; the tracing and scribing of the metal is to be done with gauges and tracing patterns.

75. The shell sheets are to be bent cold, the ends being bent according to a pattern or template and bent so as to allow a slight distance between metal and template (not bent all the way) so as to guarantee a better configuration of the finished tank. The distance between the template (1.5 meters in length) and the sheet must not exceed two millimeters directly after bending (for six-millimeter and thicker sheet). The sheets must not be twisted or warped (conicity !).

76. The sheets are to be cut and shaped mechanically or with gas cutters.

The sheets must not be cut by arc-welding methods; after cutting, the edges of the sheet must be cleaned.

With manual butt welding, the sheets 6 millimeters and more in thickness are to be chamfered at a 30-degree angle.

When the sheets are cut with gas-cutters, semiautomatic machines are to be preferred.

77. The gaps between sections to be welded together must not exceed the following values: a) in automatic welding:

butt welds (between edges) 0 - 2 mm

T-joints (between vertical and horizontal sheets) 1 mm max

lap welds (between sheets) 1 mm max

b) in manual welding:

lap joints and T-joints up to 3 mm

butt welds 2 - 5 mm.

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78. The welding of tanks must be done in accordance with the following:

a) Butt-welded seams at the edge of the bottom of the tank are to be done in two layers on the base, with guaranteed complete fusion. The welding of the base to the bottom of the tank over the entire periphery of the bottom is not permitted; it must be attached by tack-welding.

b) The vertical butt-welds on the shell of the tank are to be done on two sides, the base of the metal where the seam is to be welded being roughed-out before welding. The butt joints are to be done by the same welders who did the bottom seams.

c) The 4-mm and 5-mm sheets of individual tank shell sections may be overlapped at the vertical (otherwise butt) joints and welded continuously on the outside and at intervals on the inside. These welds can be done by welders who have qualified in accordance with Point 67.

79. After 4 or 5 sections have been mounted, the structure must be reinforced to guarantee its standing up against wind pressure.

In areas where prevailing winds are quite strong, the structure must be reinforced after the second or third section has been put up. Once the last section has been attached, the angle irons and stays are to be attached immediately, and the tank structure is not to be left standing without them.

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d) Special Precautions for Tank Manufacture and Erection in Winter

80. When air temperatures are -10°C or above, the assembly and welding work is done exactly as in summer.

If tanks have to be made ready for use in winter, they may be set up when air temperatures go down to -30° as long as TU 110-55 regulations are satisfied. When the temperature goes below 30-below, the welding must be done only after a preliminary heating of the metal. As a rule, tanks are to be assembled in winter from complete shell and bottom sections and finished covers.

82. Welding may be done in winter only under the following conditions:

a) the welders must have proper warm clothing to work in;

b) a place for workers to warm themselves must be provided within five minutes' walking distance of the construction site;

c) annealed or dried electrodes and flux must be available; only enough electrodes and flux are to be issued to each welder to last ½ working day, so that the formation of pores at the welded seams can be prevented.

Once-used flux cannot be reused unless it has been preheated.

d) A closed space or an open shelter with roof must be provided for storage of the welding equipment, unless some other weather protection is provided with the equipment;

e) weather-tight containers for the electrodes and flux must be provided at the construction site.

83. A welder is not to be permitted to do important welding on the tank (see Point 64 and Point 78) in the winter until he has successfully welded a sample sheet (500 x 200 mm), without pitting and with no incompletely fused places, in such a way as to satisfy the requirements for welding the most important tank sections.

84. The assembly of the tanks is to be done very carefully with the use of shims and clamps; the clamp is to be oversized (70-80 mm long and 4-5 mm wide).

If assembled sections to be welded get wet, the edges to be welded should be dried by heating to above 100°.

85. As a rule, the butt welding is to be done simultaneously by two welders, one on each side, with the inside work slightly ahead (500 mm) of the outside.

The butt welds on the edges are to be two-layered, the second layer being built up on the still warm first layer.

The seam where the jacket (roll) and the base (bottom) of the tank are joined is to be welded in two layers by two welders simultaneously on both sides. The second layer is applied to the still warm first layer, thus the seam section prepared for the second layer must not be over one meter in length for hand welding and 6-8 meters long for automatic welding (so it won't cool off). The T-joints are to be done by step-back welding.

86. In order to prevent pitting when welding is done in freezing weather, the following conditions must be satisfied:

a) Hand welding is done with DC (reversed polarity) with E-42-A electrodes and automatic welding is done SV-08G welding wire, containing manganese, under AR-348 flux (GV-08/A welding wire is acceptable). AC requires special ceramic fluxes (such as KVS-19), or a comparable welding procedure specified by the task at hand.

b) The welding is done with increased arc voltage and current to increase the power per unit length by 4-5 percent per 10 degree drop in temperature, whereby welding under factory conditions (plus $10^{\circ}$ plus $20^{\circ}$) is assumed to be 100%.

c) The welding involves multilayer welding by applying (building up) a second layer on the still warm first layer.

(The unit of length mentioned in b above is determined according to:

$$A = \frac{0.24 \cdot I \cdot U \cdot h}{V} \text{ kcal/cm, whereby}$$

I = welding current intensity
U = arc voltage
V = rate of seam formation in cm/sec
h = arc-power efficiency factor
for automatic welding $h = 0.85$
for hand welding $h = 0.75$.

87. Welding defects may be erased and tank accessories may be attached only at temperatures above $0^{\circ}$. At lower temperatures the places to be welded must be preheated (see Point 88).

88. The surfaces to be welded are to be heated to 150-250 degrees over a width of at least 150 millimeters on both sides of the axis of the seam. The temperature during the heating is to be checked with either a recording thermometer or according to the change of color (straw yellow color indicates a temperature of 220-245 deg, and a gray-yellow color indicates heating up to 260 degrees, etc). The heating can be done with induction-type heaters (IMA-9), resistance furnaces, multiflame burners, etc.

## III. Acceptance and Testing of the Tanks

89. The acceptance of the individual factory-produced tank sections is done by the quality control of the manufacturer, and the acceptance of the entire tank assembly and the combined individual tank sections is done by a special commission made up of representatives of the manufacturing firm, the assembly firm and the customer. The acceptance of the individual work processes and the testing of the welders are done by the firms which perform the corresponding construction and assembly (erection) work.

### 1. Assembly- and Welding-Work Acceptance after Individual Work Operations at the Erection Site

90. The individual operations are approved during the erection of the tank and include:

a) checking the dimensions of the semifinished products;

b) checking the quality of the combined sections;

c) checking the quality of the welding work.

Checking the semifinished products involves conformity with the work drawings.

Checking the combined sections involves testing the geometry of the tank sections in their combined form, the prepartion for welding and the cleanness of the welding surfaces (no dirt, cracks, rust, etc), checking to see that there are no incorrectly bent places, checking the gaps betweenparts and the quality of the clamps. There must be no cracks, slag residues, smudges, etc at the clamped places. If they are present, they must be removed.

The quality of the welding work is checked each day. It involves compliance with technical specifications, manner in which the seams are built up, the degree of gare exercised in the welding, and general visual inspection. Any faulty welds are to be corrected.

91. All welded seams are to be inspected visually. All seams are to be cleaned of burrs and dirt. Visual inspection is for the following defects:

a) cracks in the welded seam, joint, or base metal surface;

b) undercuts at the transition to the base metal; with 5-mm sheet, and thicker, such undercuts must not exceed 0.5 mm on a seam 500 mm long; deeper undercuts must be corrected by built-up welds/

c) pores in the outer surface of the welded seam;

d) protrusions on the surface of the welded seam and burned-thru spots;

e) weak spots in the welded seam and gaps in the welded seam.

Any defects discovered are to be corrected.

It is recommended that, in winter, two or three additional visual inspections be made every time there is an abrupt drop in temperature (15 degrees or more in 24 hours).

## 2. Acceptance of the Individual Tank Components

### a) Factory Acceptance

92. Tanks made up of factory-produced bottoms and shells are approved both at the factory and at the erection site, the factory accpptance by the factory quality control. The manufacturing plant must submit a record of the acceptance or approval with the equipment when it is delivered to the outfit doing the assembly work (see Attachment 3).

### b) Acceptance at the Assembly Station

93. The acceptance of the tanks (directlyon the tank bed) involves tests for leaks at the welded places by means of a vacuum method or, if such a method is not feasible, by a chemical test with silver nitrate or a phenol phthalein solution. An acceptance record must be prepared for the floor (bottom) of the tank (see Attachment 1, Form 3)

The seal of the welded seams of the bottom of the tank can be tested with petroleum, if the tank is of 700-cubic-meter capacity or less. During such a test, the bottom of the tank is to be raised off the bed.

Ammonia is fed at a pressure of at least 50 millimeters of water.

94. Tightness (leakproof) tests on the shell of the tank involve:

a) testing all the butt- and lap-welded joints with continuous outside, and intermittent inside, welded seams by copious wetting with oil;

b) testing the vertical lap-welded joints with continuous seams on both sides by introducing oil under the lap above the junction or through special openings.

The acceptance of the welded seams in this case is considered complete, if, after 12 hours (or at least 24 hours at temperatures below zero), no traces of oil can be detected on the surface of the tank.

If testing must be hurried, the oil can be smeared on the welded seams after heating to 60-70°C. In such a case the testing time can be reduced to 30 minutes.

95. Any defects discovered are to be erased, done over, and tested again. Patching the defective spots is not permitted.

An acceptance record must be prepared for the body of the tank in accordance with Form 4, Attachment 1.

96. The welded seams and angle irons of the roof of the tank are tested for tightness by one of the following methods:

a) wetting all the welded seams with petroleum under pressure from the underside of the roof; no oil spots must appear on the top (outside) surface of the roof.

b) testing with compressed air by filling the hermetically sealed tank with water or by forcing air into the inside of the tank containing at least one meter of water until (in both cases) a pressure 10 percent greater than the rated pressure for the tank is reached. During the testing, the welded seams are wet on the outside with soapy water or with foam, the formation of bubbles indicating leaks. ("Operating Instructions for the Foam Indicators Used for Tightness Tests of Welded Seams with Compressed Air in Summer and in Winter," of the Central Office for Steel Construction, Ministry of Metallurgical Industry Construction and Installation Construction for the Chemical Industry, Moscow, 1954). Any defective spots are to be done over and retested. A test record for the roof of the tank must be prepared in accordance with Form 6, Attachment 1. It is recommended that tank tops be tested in winter with oil.

97. The approval and acceptance of assembled structural supports for tank roofs is done in accordance with the "Technical Conditions for Conducting and Accepting General Construction Work and Special Construction Work," Section VII, Manufacture and Assembly of Steel Structures (TU 110-55).

98. When tanks of a 2,000-cubic-meter capacity, and larger, are set up by the "sheet metal" method, spot tests are also conducted on the vertical welded seams of the body of the tank by either gamma-ray methods or with a recording magnetometer (so-called "magnetographic" testing). One of these additional tests is to be conducted on the entire surface of the vertical butt-welded seams in the first course (lower section) of the tank body and on 50 percent of the butt welds of the second and third courses, and (all) the butt-welded seams at the edge where the body and bottom of the tank meet.

In each test of the butt-weld to be examined, a section 200-250mm long (one film) is exposed, the spot being decided by the customer. Recording-magnetometer tests are to be conducted before the tank is filled with water.

A test record is prepared in accordance with Form 5, Attachment 1.

99. The butt-welds are declared faulty if the tests show the following:

a) any large cracks in any direction;

b) places not completely fused;

c) slag inclusions or voids (Group A and B, GOST 7512-55) amounting in size to more than 10 percent of the thickenss of the wall;

d) slag inclusions of a chain-like configuration or which form a continuous line along the welded seam (Group B, GOST 7512-55) covering a total length of at least 200 millimeters per meter;

e) clusters of gas bubbles

f) isolated gas-bubble clusters in individual segments of welded seams (Group V, GOST 7512-55) occurring at a rate of more than five per cubic centimeter.

100. If either of the two above testing methods reveals defects in a welded seam, a second testing on the seam is conducted at twice as many places. If the second test shows additional defects, the entire seam is to be tested and corrected.

3. Final Acceptance of the Completed Tank

101. The final acceptance of tanks involves a visual check on the geometry of the structure, a water test, and chekk on agreement with earlier prepared testing records in accordance with appropriate specifications.

102. The delivery of the completed tank must be accompanied by the following documents:

a) technical records of the factory-produced components;

b) certificates (or copies thereof) and other data indicating the quality of the construction material, the electrodes, welding wire, flux, and any other materials used in the manufacture or erection of the tank;

c) records of the excavation work performed and intermediate test records of the acceptance of the type of soil used in preparing the supporting ground of the tank, the dry bed and moisture-insulating layer, tightness tests conducted on the body, bottom and roof of the tank, test records for the piping and other accessory equipment, the grounding of the tank as specified in the plans, and the record of gamma ray or recording-magnetometer tests on the vertical welded seams.

d) proof of completion of erection of tank and proof of completion of the welding work.

103. The final test involves filling the tank to the full mark with water.

The tank passes the hydraulic test if, after standing full of water for 24 hours, no leaks can be detected anywhere and no lowering of the water level in the tank has taken place. Any defects or leaks are rewelded (no patching is permitted), and the repaired places tested with petroleum. For the hydraulically tested tank, an acceptance record is prepared in accordance with Form 5, Attachment 1.

During the testing, the welded seams are to be examined very carefully for cracks and other defects; if cracks are discovered in the body of the tank, the testing is to be held up, and the water allowed to run out of the tank until the water level inside reaches one section below the defect (but not below the 5th section). The use of any paste, cement, plaster, or caulking to stop a leak temporarily during testing is categorically prohibited. The test is resumed after the cracks and other defects have been corrected.

104. In winter, the leakage test of the tank is done with water or with the product to be stored in the particular tank, according to special agreement with the customer based on concrete testing conditions.

When the tank is tested with water, special measures must be carried out to protect the water from freezing in the pipes, valves, and on the outside of the tank; these measures include the provision of continuous circulation of the water, the heating of individual sections of the tank and joints, as well as the heating of the water. The tightness (leakage) tests are conducted in accordance with the conditions already stated in Point 103 above.

105. In the testing of the shape and dimensions of the tank, the following deviations from the design are allowed:

a) diameter of the tank at the level of the bottom of the tank: plus-minus 0.002 max

b) height of the tank: plus-minus 0.05 h max

c) the deviations of the outside lines of the 2,000-5,000-cubic meter tanks from the vertical may not exceed the values given in Table 1; those deviations from the vertical in the case of 1,000-cubic-meter tanks must not exceed the values given in Table 1 multiplied by 0.7. Excessive vertical deviations are to be corrected. The vertical deviations are measured at 8-12 places (depending on the size of tank) after the profile test has been conducted on the tank filled with water (with steel wire 1.5-2 mm thick suspending a 10-kg weight in a vessel filled with water or petroleum;

d) bumps and depression s in the bottom of the tank must not be over 150 millimeters. If they exceed this height or depth, they must be filled in with material used for the insulating layer under the tank, with care being exercised to see that the insulating layer is not damaged or penetrated. In the case of bumps, 200-250-mm holes can be made in the bottom, the material removed from under the bump, and a patch lap-welded over the holes. The repaired places are tested for tightness by vacuum. The weldments of patches on the bottom must not be closer than 500 millimeters from the welded seam where the body and bottom of the tank meet.

106. The outside of thetank and of the top of the tank must, after being tested, be painted with a waterproof and nonreflecting paint, and the bottom of the tank must be cleaned.

An acceptance record in accordance with Form 7, Attachment 1, must be prepared. The customer issues the receipt for the tank.

The manholes and hand holes are closed and soldered; the inspection holes remain open.

TABLE 1.

Admissible Deviations of the Side of the Tank from the Vertical

| Vertical Section | Outward deviation from the vertical along the outer edge of the first vertical section (mm) | | Inward deviation from the vertical along the outer edge of the first vertical section (mm) | |
|---|---|---|---|---|
| | rolls | sheets (plates) | rolls | plates (sheets) |
| 8th | 70 | 50 | 130 | 150 |
| 7th | 65 | 45 | 110 | 135 |
| 6th | 60 | 40 | 95 | 125 |
| 5th | 55 | 35 | 75 | 100 |
| 4th | 45 | 30 | 60 | 80 |
| 3d | 35 | 25 | 45 | 65 |
| 2d | 25 | 20 | 30 | 40 |
| 1st | 15 | 15 | 15 | 20 |

If there are horizontal undulations in the surface of the tank, the sag or dip values must not exceed the figures given in Table 2.

TABLE 2

Admissible Sag or Dip of Horizontal Undulations in the Surface of the Tank Body

| | | | | | | |
|---|---|---|---|---|---|---|
| Thickness of the Tank Wall in Millimeters: | 4 | 5 | 6 | 7 | 8 | 10 |
| Sag or Dip in Millimeters: | 30 | 40 | 50 | 60 | 60 | 60 |

Pages 53-88 [Part 3] are missing.

/Part 3:/ pages 53-88 are missing.

/Part 4/ pages 89-147 follow:

.....edge of at least one meter width consists of 8-millimeter sheet, and 5-millimeter sheet thicknesses are used for the inside sheets of the floor. The welding of the inside sheets with the thick edge sheets is done in this case by lap-welding.

Worth particular mention is the fact that, in contrast to the well-known procedure, the 4th course from the bottom is welded with crosspieces. When we questioned this procedure, our Soviet colleagues answere that this method posed no difficulties in acceptance and is done with the approval of the supervisors. They do, however, conduct more intensive tests on the crosspieces. The testing of the welded seams will be dealt with specially below.

The cost for the welding equipment was given as about 200,000 rubels, not counting the accessory welding devices which amount to an additional 50,000 rubels.

A tank of 5,000 cubic meters capacity and weighing 93 tons costs 175,000 rubels to erect. At this weight, the shop work, without assembly (setting up), amounts to about 1,100 rubels per ton. This manner of comparing costs, however, should be approached with caution, since conditions can vary over too wide a range. It is thus better to compare completion times and weights of materials used in order to arrive at factors which can be weighed against our own figures.

3. Concrete and Reinforced Concrete Tanks

Concrete tanks for the storage of heavy and light oils are already in continuous production in the USSR. These tanks are, however, most favorable for the heavy oils. These tanks are made from prefabricated parts in order to guarantee a better chance of exchange and maintainance. The shape is round for up to 5,000 cubic meter capacities, and from 5,000 to 10,000 capacities it is square. The relatively heavy tops are supported by columns, and stairs are provided to get down into the tanks.

The tanks are erected so that the top of the tank is at the level of the ground, so that certain technical safety advantages can be exploited. The pressure ratings in these designs are given as:

| | |
|---|---|
| excess pressure: | 800 - 900 millimeters (water column) |
| vacuum pressure: | 50 - 60 millimeters (water column) |

/Page 90 of document shows side and plan views of an underground reinforced-concrete tank with a capacity of 2,500 cubic meters./

/Page 91 of document shows similar views of a 5,000-cubic-foot concrete tank./

The insulation of the concrete poses particular difficulty. The best results have been obtained, according to the Leningrad Design Bureau, by using a coarse grained concrete and insulating with water. This method was used particularly for tanks holding the heavy oils, and additional insulation was provided by a sheet-metal jacket. Tanks holding light oils are insulated with plastic, which is either spread or sprayed on.

The ventilation of these tanks is done in the usual way. The Leningrad Design Bureau estimates the life of such tanks to be 50 years.

"Drop-Shaped" Tanks (by Safaryan)

Drop-shaped tanks (Fig 8) are used to store volatile petroleum products under an excess pressure of 0.4 atmosphere gauge.

/Page 93 contains drawings of a drop-shaped tank./

The possibility of the development of a vacuum up to 300 mm (water column) during the pouring off of the petroleum product or during the cooling of the jacket at night was taken into account in the calculation of the jacket of the tank.

Investigations (data given by an engineer, S. I. Verevkin) have shown that the loss of petroleum product in the drop-shaped tanks (Table 3) is appreciably lower than in the upright cylindrical tanks.

Table 3

| Number of Fillings per year | Standard Tanks 4,600 cub m. | | Drop-shaped tanks 4,600 cubm | | Reduction of loss in drop-shaped tanks in ratio to standard tanks |
|---|---|---|---|---|---|
| | $m^3$ | % | $m^3$ | % | |
| 2 | 165.6 | 3.6 | 15.8 | 0.33 | 11-fold |
| 12 | 303.6 | 6.6 | 82.8 | 1.80 | 3.7-fold |
| 36 | 634.8 | 13.8 | 246.0 | 5.40 | 2.6-fold |



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Experiments have also shown that the drop-shaped design affords weight reductions by eliminating the inside suppòrting system and some segments of the supporting ring. The table below gives some data on comparative use of metal for the ordinary upright cylindrical tanks of the 1952 plan, the drop-shaped tanks of the 1948 plan of the State Institute of the Planning of Speċial Petroleum Installations and the drop-shaped tanks of the light-weight type designed by G. M. Chichko (State Institute of the Planning of Special Petroleum Installations).

Table 4

| Type of Tank | Capacity cubic meters | Excess Pre-sure (mm water) | Vacuum Presure (mm watèr) | Total Amount of Metal Used | Kilograms of Metal per $m^3$ of capacity | Relative Amount of Metal Used % |
|---|---|---|---|---|---|---|
| Upright Cylindrical Welded | 2,000 | 200 | 25 | 41.0 | 20.5 | 100 |
| Drop-shaped according to Project 1948 | 2,000 | 4,000 | 300 | 63.3 | 31.65 | 155 |
| Light-weight Drop-shaped Design | 2,000 | 4,000 | 300 | 51.3 | 25.65 | 125 |

As can be seen from the table, the use of metal for the drop-shaped tank of the light-weight design is only 25 percent greater than for the cylindrical tank. The cost of the metal work on the drop-shaped design is thus only 11.3 percent higher than that of the metal work for the cylindrical type.

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The slightly higher cost of the drop-shaped tank is compensated by the considerable reduction of losses of petroleum products and preservation of the quality of the latter.

## Results of Experiments With the 2,000-cubic-meter Tank

The drop-shaped 2,000-cubic-meter tank was tested as follows:

a) with a grill-type supporting structure: with hydrostatic water pressure at full-tank according to regulations (7.5 meters) and an excess pressure of 4,400 mm (water column) instead of 4,000 mm (water column) as given in regulations.

b) without a grill-type supporting structure: 4,300 mm (water) pressure at full tank (7.5 meters) and a vacuum of 500-mm (water), instead of the 300-mm (water) called for in regulations.

The tank withstood the test conditions without any damages or defects.

The experiences gained by the Central Office for the Erection of Petroleum Installations in the building of four drop-shaped tanks for the Pavelets Petroleum Supply Center proved the possibility of the factory production of such tanks and the feasibility of extensive use of such tanks in the petroleum industry for the storage of volatile petroleum products with an excess pressure of 0.4 atmosphere (gauge) and a vacuum of 300 millimeters (water column).

The weight of the drop-shaped design can be reduced by doing away with the inside grillwork supporting members and reducing the thickness of the jacket at the equitorial line to 5 millimeters (instead of the usual 6 millimeters). Below the



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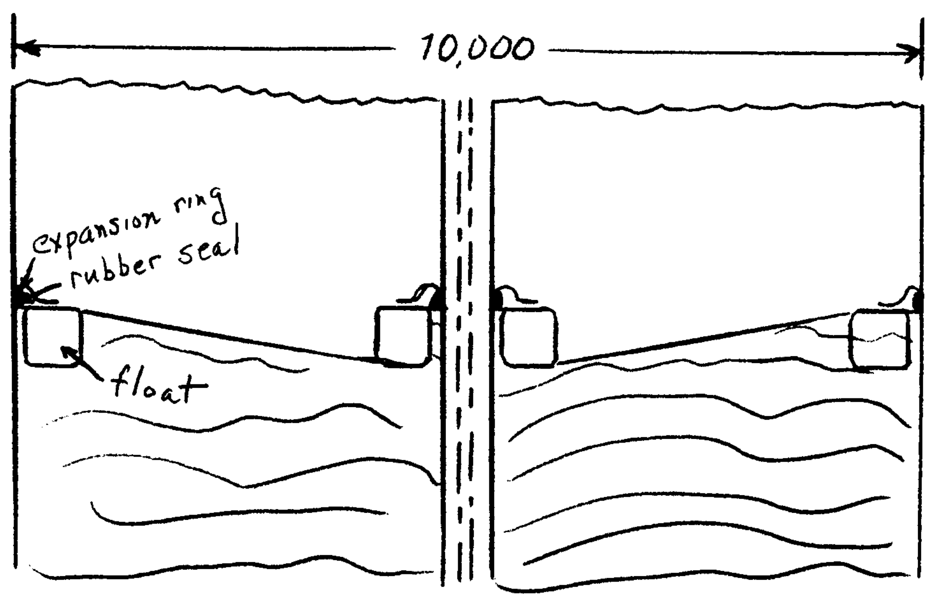
equitorial line, the jacket is 8 millimeters thick. Furthermore, the weight of the supporting ring can be reduced by doing away with the outside grillwork which reinforces the ring, and by changing other designs. Weight reduction from the absence of the inside grillwork and the reduction of the weight of the ring amounts to about 20 percent.

G. M. Chichko's suggested design for the drop-shaped tank with equitorial support provides even better saving of metal than the design described here. The design described here, with 20 percent saving of metal, is recommended for introduction into the national economy.

Tanks with Floating Tops

Four floating-top tanks (200 cubic-meter capacity each) were inspected at the Paveltrovskiy tank depot. All of them had the standard top construction with ventilation. The floating top is designed as shown below.



The seal is provided by two leather sleeves, which provide a good seal as the floating top moves up and down. When the roof was raised, scarcely a trace of oder from escaping volatiles could be detected in the area above the floating top. At present, these tanks are being built in the USSR for capacities up to 400 cubic meters. The tank covers are to be made of canvas to protect them against natural attack by water. With this type of tank, the escape of volatiles is reduced to a minimum (to 10 percent), thus the type is used to store lighter oils.

A presently secondary, but expanding, idea for obtaining additional tank storage space is that of underground storage. This is done by washing out the salts with water and using the resultant space as storage. Since the salts do not combine with the oils, the oil can be stored for long periods. The possibility of this type of storage within the economy of the GDR might be investigated.

## Typical Tank Designs

### Tanks with Sheet-metal Covers and Center Supporting Column

Upright welded cylindrical 5,000-cubic-meter tank (designed by the Central Office for the Erection of Petroleum Installations): These are the usual standpipe types but have a grillwork center supporting column, which rests on the bottom of the tank and has a supporting ring at the top. The tank is about 22.8 meter in diameter and 11.6 meters high; the height of the cover is about 0.57 meter.

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The illustration shows a schematic of the 5,000-cubic-meter tank suggested by engineers V. M. Didkovskiy and G. V. Silbershmidt of the Kuybyshev Metal Construction Works under the Central Office for the Erection of Petroleum Installations.

The individual roof sections have a bent trapezoidal shape. In order to impart a structural unity to the segments, each panel is composed of two parts, one trapezoidal and one triangular. The length (radius) of the segments is 10.1 meters. The supporting section of a single segment consists of a grillwork beam attached on the long side of the trapezoid. The other sides of the segment have angle irons along the edge. Not counting the center panel, there are 11 segments in all. Each segment weighs 1,567 kilograms (counting the triangular piece). The panels are reinforced by transverse T-irons, welded on from below.

The roof segments are assembled as follows:

The center supporting column is set up on the already laid tank bottom, and reinforced. The rolled sheet-metal tank jacket (body) is then set upright on the tank bottom as close as possible to edge of the bottom on a special sheet. Then the roll is unrolled and the top segments laid on with one end supported at the center column and the other at the tank jacket. The roof segments are mounted with a special lifting crane, the hook of which grabs at the center of gravity, the horizontal lifting guaranteed by the use of pad-eyes attached to the segments.

On the outside edge of each segment are four "catches," which make it possible to set up and fasten the segments without using a manhole or otheropening.

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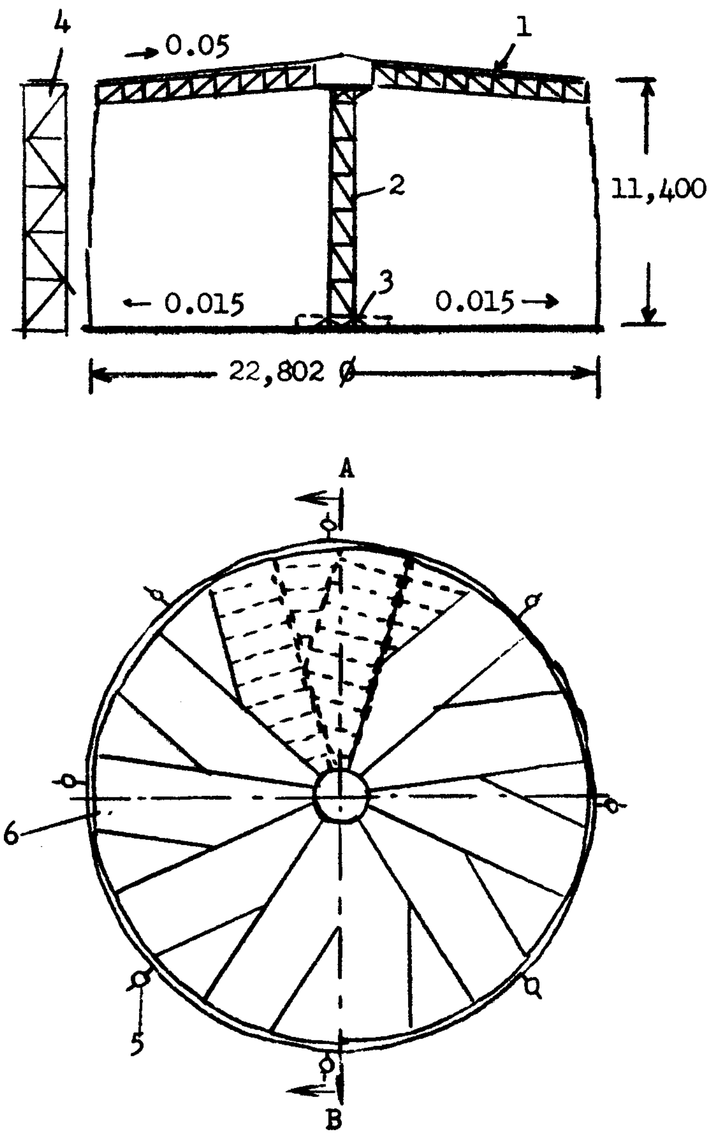


**5,000-cubic-meter tank**

1. sheet-metal panel cover
2. center supporting column
3. base of center column
4. stairs with landings
5. indicator
6. cover panel

Each successive segment is attached to the one already set up in such a way that there will be an overlap of 30 millimeters. All segments, except the first and last are welded together as they are put up. The first and last are welded after the tank jacket has been set up and welded.

The center panel is attached after the entire top has been put up. The center panel is 2.6 meters in diameter and weighs 142 kilograms.

The roof is designed for the following loads:

| | |
|---|---|
| snow: | 100 kilograms per square meter |
| heat insulation: | 45 kilograms per square meter |
| vacuum pressure: | 25 kilograms per square meter |
| its own weight: | 40 kilograms per square meter (approximately) |
| excess pressure: | 200 kilograms per square meter. |

With an excess pressure of 200 kilograms per, the lifting force amounts to about 80 tons (200 kg square meter), which is greater than the weight of the cover plus the body of the tank; about one-third of this force (27 tons) is supported by the central column, and two-thirds by the jacket. The jacket and a portion of the cover compensate a portion of the lifting force with their weight. The equalization is not guaranteed by the center column and middle panel of the top. In order to avoid a lifting of the center column, it is weighed down with a 9-cubic-meter base of concrete (about 20 tons).

Tests conducted on the upright cylindrical tank with sheet-metal cover and central supporting column show that an increase of the excess pressure in the empty tank causes a lifting of the tank body together with the center supporting column.

For a lifting to take place, it is absolutely necessary that the pressure which is applied to the roof exceeds the weight of the tank jacket, of the center column, of the small bottom ring attached to the tank body and to the center column.

In view of the fact that the roof surface is 410 square meters and the total weight of the elements which counteract the lifting force is about 73 tons, an initial lifting can be expected at an excess pressure of about 180 millimeters (water column). This does not take into account those additional forces required to bend the corresponding portions of the bottom before the lifting begins.

Experiments have shown, however, that a lifting actually occurs at much smaller excess pressures. At only 50 millimeters (water column), the lift amounts to 1.68 mm, and 2.54 mm at 80 mm (water column).

These values do not characterize the actual lifting, but rather the elastic deformation of the bottom. The bottom elements are deformed by the weight of the body and roof of the tank during the application of the roof. If an excess pressure develops inside the empty tank, however, the vertical component of which, with its upward force, tends to decrease the pressure from the weight of the tank and the roof, then the load on the bottom elements is relieved, allowing them once more to assume a horizontal position.

 

The actual lifting of the tank body does not occur until the excess pressure reaches 180-200 millimeters (water column), that is, until the excess pressure exceeds the total weight of the tank body and the roof, plus part of the weight of the bottom.

With high excess pressures, the lifting is more intensive. For example, the lifting amounted to as much as 23 millimeters when the pressure went up to 250 millimeters (water column). The lifting in this case was not uniform; the lifting was almost entirely on one side. That side of the tank to which the pipelines are attached, for example, did not rise at all during the first phase of the lifting, but rose only slightly after the pressure increased much more; the opposite side rose considerably more.

The lifting is considerably more in the zone of the central column than elsewhere. At a pressure of 120 millimeters (water), it was 44 millimeters; at 200 millimeters of water, it was 90 millimeters, and was 112 millimeters at a pressure of 250 mm. In the latter pressure range, the lifting is considerable and has to be compensated by increasing the weight of the central column. This can be done by attaching a heavy concrete base to the column or by making the column out of welded pipe and filling it with sand (Plan of the State Institute for the Planning of Special Petroleum Installations, 1955).

Experiments showed that the stresses in the empty tank during lifting (within the above-mentioned pressure ranges) do not exceed 200-250 kilograms per square centirmeter, which is not great. From the standpoint of stability, such a lifting is therefore not dangerous.

 

During the testing of the tank considered here for lifting values, the foot of the eentral column was weighted with about 20 tons of concrete. The deformations of the vertical profile decreased by about a factor of two. The vertical deformations in the central column at the same time decreased by a factor of from 4 to 7. The tank was then filled to the top with water, and the stresses in the lower part, as well as the bulges of the tank profile and buckling of the central column, were measured. The bulging of the tank profile fluctuated between 10 and 60 millimeters, and the buckling of the central column from the computed vertical loading amounted to 20 millimeters.

The stresses in the lower zone of the tank caused by the hydrostatic pressure did not exceed 1,200 kilograms per square centimeter. The stresses in the elements of the tank roof did not exceed 840 kilograms per square centimeter. The stresses in these elements caused by the vacuum pressure remained under 710 kilograms per square centimeter. These stresses are lower than the admissible stress values.

2,000-cubic-meter Tanks (Design: Central Office for Assembly of Petroleum Installations)

The suggestion of engineers V. M. Didkovskiy and G. V. Silbershmidt of the Kuybyshev Metal Construction Works regarding the erection of upright cylindrical tanks with factory-made sheet-metal tops was first carried out in the construction of 2,000-cubic-meter tanks.

The roof sections are connected with [-irons and angle-irons, which gives them sufficient rigidity for transport and takesup the vertical loads during operation.

The attachment of the roof segments to the tanks, which were inspected, was done by No. 14-a [-irons; the transverse ribs located about in the center of gravity of the panels were made of No 10 [-irons and 90x60x6-mm angle irons.

The weight of the 15 segments (panels) and the center panel was 8.0 tons. The weight of the central supporting column was 1.78 tons.

The tank was tested at an excess pressure of up to 260 millimeters of water (instead of 200 millimeters as given in the regulations) and at computed vertical loads of 280 kilograms per square centimeter (instead of 170 kilograms per square centimeter as prescribed by regulations). An additional hydrostatic test was conducted by filling the tank to the top with water.

The tank passed these tests without any indications of impairment of strength or rigidity.

The test indicated the following:

1. The stress values and the bending values for the ribs of the sheet-metal cover did not exceed the admissible values.
2. The bending of the bottom of the tank at an excess pressure of 200 millimeters (water) did not exceed 4 millimeters, which is entirely admissible. In view of the very slight lifting, one may concluded that it is quite feasible to dispense with the counterweights called for in the type plan for the year 1952.
3. The lifting of the central column at an excess pressure of 200

millimeters (water column) inside the empty tank did not exceed 18 millimeters. At such a small lift, the counterweight for the central column is not required.

4. The bending of the bottom at the center of the column in the water-filled tank did not exceed 10 millimeters, which is completely admissible and indicates the probability of dispensing with the special foundation under the central column.

Compared with the traditional roofs of girders, ribs and radial beams, the segmented tank roofs show the following advantages:

a) They afford the possibility of factory-assembly and thus a reduction of the construction time;

b) they afford the possibility of improving the quality of the welding work as a result of factory-production of the sheet-metal panels with ready-to-install dimensions;

c) they provide a decrease of work operations and number of elements handled during construction, thereby simplifying the construction process;

d) they provide for a saving of personnel and steel.

Drawings on page 104: Top - <u>2,000-cubic-meter tank</u>

1. sheet-metal panel roof
2. central supporting column
3. concrete base of central column
4. ladder with landings
5. standard type roof panel
6. roof panel with entrance hole
7. central panel

Bottom - <u>5,000-cubic-meter tank with sectional roof panels</u>

1. sheet-metal panel roof
2. central supporting column
3. concrete reinforcement
4. roof panel

Drawings on page 105: Top - <u>5,000-cubic-meter tank with straight-cut sheets as roof panels</u>

1. sheet-metal roof
2. central column
3. roof panel

Bottom - <u>2,000-cubic-meter tank</u>

1. sheet-metal roof
2. central column
3. roof panel

5,000-cubic-meter tank - Designed by State Institute for Planning of Special Petroleum Installations

The tank with the cover made of sheet-metal sections was planned with the possibility in view of rolling the tank body and the tank floor (bottom).

The tank roof is planned as consisting of trapezoidal sheet-metal panels with ready-to-install dimensions. The central supporting column is made of grillwork and suitable to hold the rolled-up floor of the tank.

See page 104 for a schematic of the tank.

The diameter of the tank is 22.79 meters, it is 11.845 meters high, and the roof structure is 570 millimeters high; the sheet-metal panels are 9.545 meters long and weigh 1,717 kilograms (including the triangular piece); the central panel weighs 1,948 kilograms, is 3.8 meters in diameter,and the central supporting column is 11.88 meters high and weighs 1,345 kilograms.

The jacket of the tank has the following special features:

1) The vertical welded seams on all eight sections are butt-welded, the vertical seams of the four lower sections running in a straight line; the seams are staggered on the upper four sections.
2) The horizontal welded seams on the four lower sections are likewise butt-welded. The welded seams between the 4th and 5th sections and the seams of the upper sections are lap-welded. The connections between the individual sections of the tank differ from the type plan of the Central Office for Planning of Industrial Installations, 1953, in that they are not telescoping, but mixed (blended).





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3) In view of the fact that the sheet-metal panels are lower than the supports of earlier designs, and in order to increase the three-dimensional rigidity and ability to withstand wind loads and vacuum pressure on the part of the upper zones, the thickness of the 7th and 8th sections is 5 millimeters instead of the 4 millimeters provided by the 1952/53 plan. For the same purpose, I-beam supports are added in the 7th and 8th zones, where they are tack-welded to the sections. These supports also serve as a bearing point for the supporting elements of the roof. The sheet-metal panels, including the center panel, weigh 22.135 tons.

The diameter of the bottom of the tank must be about 100 millimeters larger than the diameter of the tank, since the outer ring of the bottom of the tank is supposed to extend 40 millimeters beyond the body of the tank (accounting for the thickness of the bottom section of the body of the tank). The bottom of the tank usually has a somewhat larger diameter, and the outer ring of the bottom is enlarged as required at the construction site.

No foundation is laid under the center supporting column. The bottom of the center column is weighted with concrete (11 cubic meters) in order to compensate the vertical forces which are produced in the empty or almost empty tank by the excess pressure of 200 millimeters of water.

Three different designs are suggested for the center column: a gridwork design with concrete-weighted base and a steel-pipe design, 1,220 millimeters in diameter welded from 8-millimeter steel sheet.

The pipe is filled with sand to produce counterweight. The amount of sand used is 13 cubic meters. The pipe-column is designed for rolling up the sheet-metal tank bottom, thus, in addition to the upper and lower reinforcements, there are two intermediate reinforcing rings 2,660 millimeters in diameter of [-iron 12.

Tanks with roof made of straight-cut panels:

The design of the body and floor of this type tank is the same as that described above. The difference in this tank is the fact that the roof panels are cut in straight lines, and the center supporting column is a pipe made by welding 8-mm sheet steel (illustration). The supporting column weighs 4.164 tons. The pipe is filled with sand.

The center panel is square in shape. In all, 16 sheet-metal panels (not counting the center panel) are used. The total weight of the panels, including the center panel, is 20.288 tons. The weight of the sheet-metal panels for this variation is 1.847 tons less than for the first design variation.

The weight of the central supporting column is 2.819 tons greater than the weight of the center column of the first design variation. The total weight of the metal work is, in the second variation, greater than the total weight of the metal work of the first, and amounts to 90 tons (as compared with 89 tons for the first).

Experimental tank assembly showed that the sectional roof design is the more favorable one.

2,000-cubic-meter tank (Design by Central Institute for the Planning of Special Petroleum Installations)

As in the case of the 5,000-cubic-meter tank, this tank body and bottom have been designed for the possibility of being rolled (up). The jacket of the tank is rolled up on the ladder tower, and the bottom of the tank is rolled up on the central supporting column in order to facilitate transportation to the construction site. The tank has the following special features:

1) The vertical seams of all the sections are butt-welded.
2) The welded seams between the individual elements of the two lower sections are likewise butt-welded, the vertical welds running through both sections in a straight line. All other seams of the upper sections are lap-welded, the vertical seams being staggered.
3) In the zone covered by the 3d to 8th sections, the sheets are not telescoped.

The tank is 15.18 meters in diameter and 11.8 meters high; the center column is 11.88 meters high, and the roof slope is i = 0.05.

The metal body of the tank weighs 21.6 tons; the individual sheet panels weigh 0.543 ton; the 14 main panels (roof) and the center (roof) panel weigh 7.7 tons, and the center supporting column weighs 1.345 tons.

The bottom of the tank is 100 millimeters larger than the diameter of the tank.

The center column is weighted at the bottom with concrete in order to compensate the vertical forces produced by an excess pressure of 200 millimeters (water) in the empty or nearly empty tank.

Tests showed that the vertical displacement of the bottom profile of the empty tank does not exceed 4 millimeters at an excess pressure of 200 millimeters of water column; under these conditions, the center column does not rise more than 18 millimeters.

By comparing the weight of the body of the tank, of the roof and center column with the vertical force produced by excess pressure (200 kg x 175 $m^2$ = 35 tons in this case), we get the following:

| | | |
|---|---|---|
| Weight of tank body: | 21.6 tons | |
| Weight of the sheet-metal panels (roof): | 7.7 tons | |
| Weight of the center supporting column: | 1.3 tons | |
| | 30.6 tons | < 35 tons |

Thus the weights lack about 5 tons required to compensate the excess pressure (not counting the weight of the outside bottom ring and the center part of the bottom of the tank, which counteract the lifting of the tank body, nor the weight of the fittings and pipes for the stored petroleum product, which have a similar counterlifting effect).

It might also be noted that, under operating conditions, the excess pressure does not occur immediately, but only after a certain volume of petroleum products (which themselves represent additional weight) have been put into the tank.

At first, when the tank still contains very little petroleum product, the stresses produced by the lifting of the tank body are slight (not more than 200-250 kg/$cm^2$) and thus represent no great danger. The lifting of the tank diminishes steadily as more liquid is fed into the tank, that is, when the stresses produced by hydrostatic pressure increase and computed (lower than admissible) values are reached, the possibility of the lifting of the tank is out of the question.

Experiments have shown that the counterweights on the outside of the 2000-cubic-meter tank (provided by the Central Office for the Planning of Industrial Installations) are superfluous. The counterweights for the center supporting column in the tanks with sheet-metal panel roofs are likewise superfluous.

(End of the excerpt from the translation of the draft for Technical Conditions for the Manufacture and Erection of Welded Cylindrical Tanks)

## Procedures for Welding and Testing

Continuous improvement of technology through the use of modern methods requires a careful study of these procedures. For this reason, certain institutes in the USSR have been assigned the task of developing these procedures to perfection so that they can be introduced into industrial practice. The Scientific-Research Petroleum Institute in Moscow is concerned solely with these problems. The introduction of automatic, or at least semi-automatic, welding is a prerequisite to the increase of work productivity. The considerable mechanization of the manufacture of the "rolled tanks" was thus only possible through the use of automatic welding under powder. At the large welding facility in KUYBYSHEV, four welding tractors, two on each stage, worked continuously in order to produce the jackets and bottoms of the "rolled" tanks. At present, the tractors are operated by both experienced and inexperienced (trained and untrained) personnel (welders). Four-millimeter SW-08 (SV-08) A, or SV-08 G (A) welding wire (GOST 2246-54)is used, and the welding powder is type AN-348-A.

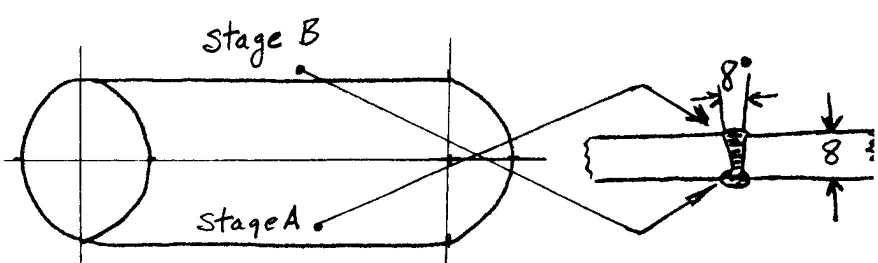
The following values were given for an analysis of the wire:

Welding Powder AN 348 A

(composition of the wire)

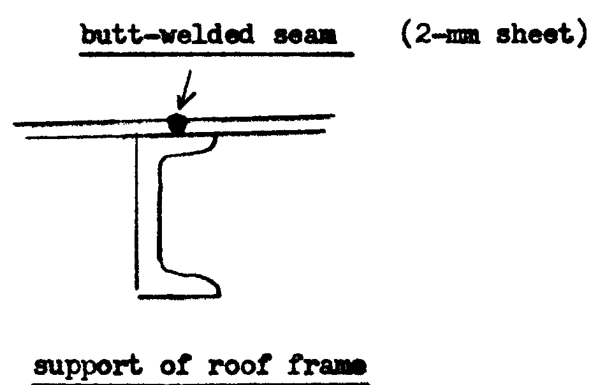
| | SV-08 | SV-08-A |
|---|---|---|
| Carbon: | 0.10 | 0.10 |
| Manganese: | 0.35-0.60 | 0.35-0.60 |
| Silicon: | 0.03 | 0.03 |
| Chromium: | 0.15 | 0.10 |
| Nickel: | 0.30 | 0.25 |
| Sulphur: | 0.04 | 0.03 |
| Phosphorus: | 0.04 | 0.03 |

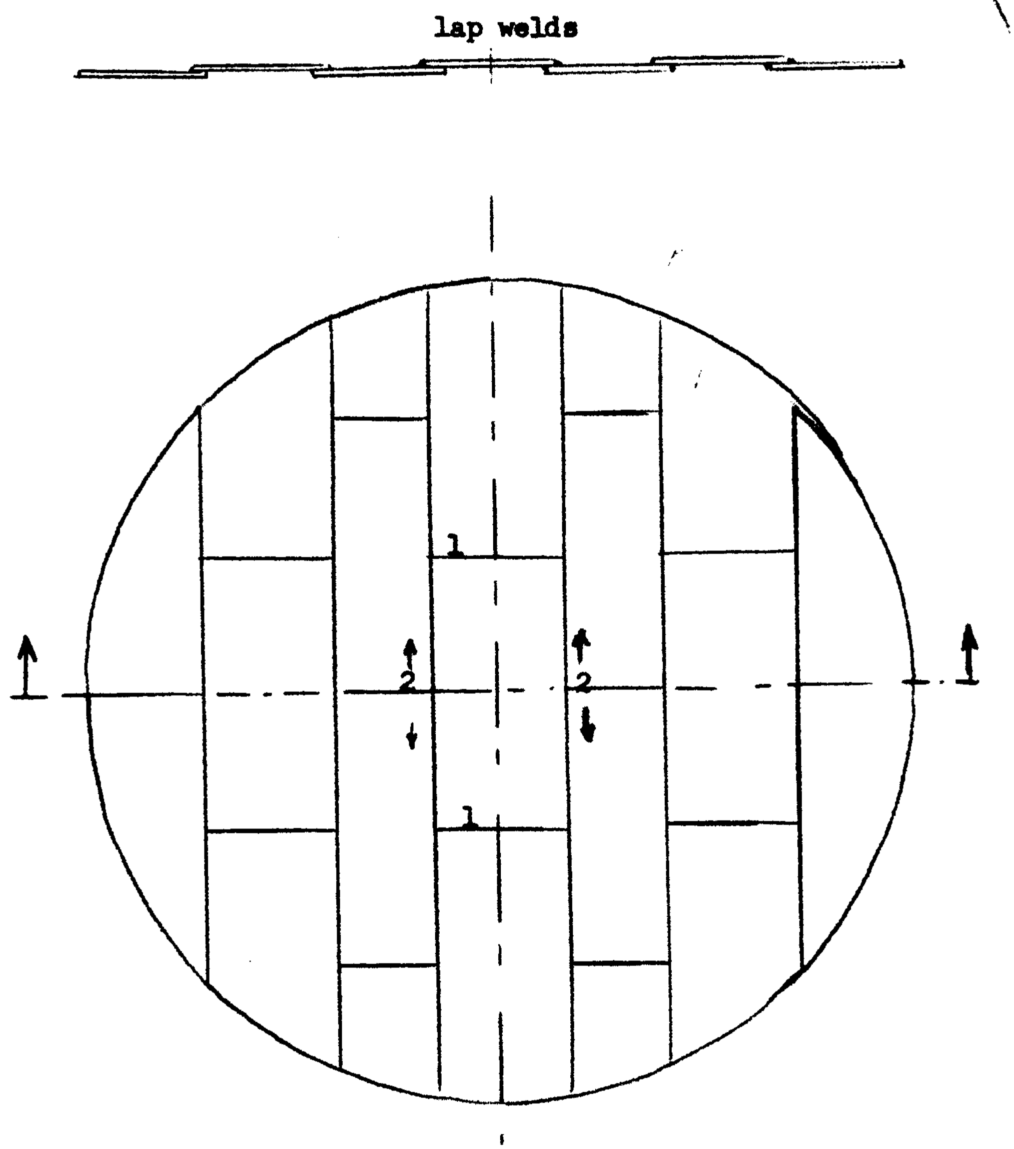
In the case of the tank jacket, the 6-10 millimeter sheets are welded with a weld-clearance of 1-2 millimeters, whereas with thinner sheets the sections are joined butt to butt. The welding sequence is of secondary importance, since the magnetic clamping device provides a satisfactory adhesion of the sheets. The welding is done with one layer (course) on each stage.



An analogous procedure is followed in the welding of the bottoms.

Lighter tractors are used to weld the roof cover, and 2-mm welding wires with up to 270 amperes of current are used. They gave the welding rate for this case as 63 meters per hour, using patterns and templates, which guarantee a satisfactory course of welding.

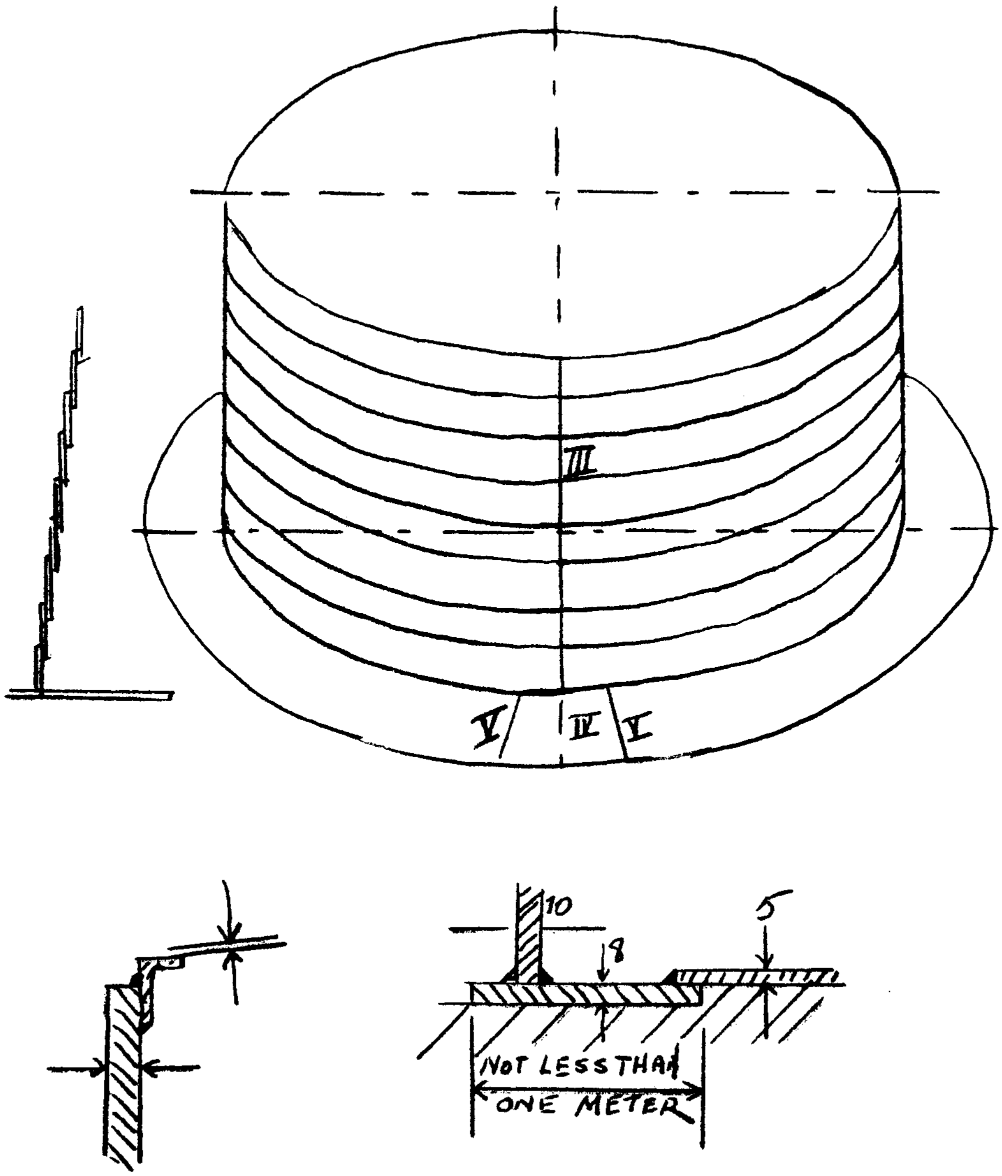





**Welding Sequence:** 1. Transverse seams welded with gap of about 2 millimeters

2. Longitudinal seams lap-welded with fillet on one side A = 0.7 sheet thickness ffom inside outward.

**BOTTOM (FLOOR) SECTIONS FOR TANKS (WELDING)**




**Sequence of Welding the Tank**





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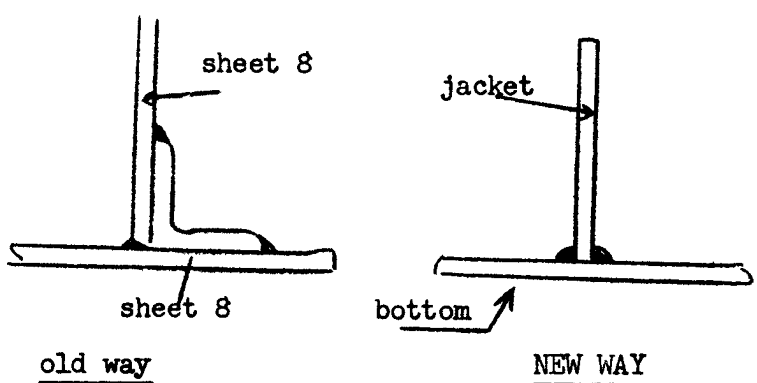
Since the sheet-metal sections are always welded to the [-irons of the roof constructions, care is always exercised to provide a good foundation for the welding under powder.

At times some welding under powder was done at the construction site also, even though the necessity of doing so was not indicated in all cases.

Tendencies and trends in the building of tanks is toward doing as much of the fabrication as possible in the shop, so that the operations at the construction site will be reduced to a minimum. Essentially, the construction-site operations involve only: welding the two halves of the bottom, welding the jacket with the bottom and top and welding one longitudinal seam on the jacket. Experiences have shown that using a corner angle-iron in welding the jacket to the bottom is not necessary. Actually, the additional stresses caused by welding the angle-iron in the corner and by large temperature fluctuations led to a breaking of the angle-irons.



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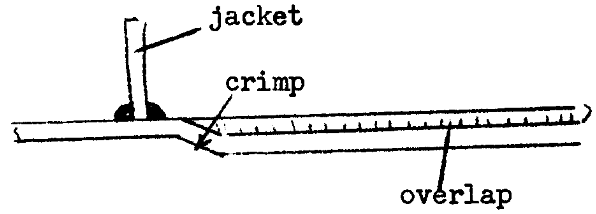
In the case of welding at the construction site, special attention was given to the dry storage of the welding equipment and satisfactory preparation for welding. Welding was done at temperatures down to minus 30 degrees (C), with the welding wire preheated to 300 degrees (C) and a 4-percent increase of current used during the welding. The work itself was not preheated. In the case of the "roll-type" tanks, the jacket was welded to the bottom with the step-back welding method.

In the case of the erection of tanks of the customary type (not rolled up), an attempt was made to determine whether special procedures of welding and assembly have been developed in the USSR. It was found that, while the welding and assembly work on the jacket and top of this traditional type tank had been done in the ordinary way, the following procedure proved to be most advantageous in putting the bottom of the tank together:

The sheets for the bottom are laid out in lines and the transverse seams are welded first. Then, after the longitudinal lines have been welded, the laps are welded as shown in the illustration, from the center outward. The value A is given here as equal to 0.7 of the sheet thickness.

To the question of whether the laps on the underside, which, in this case, are not welded, would not be subject to corrosion, it was answered that no corrosion could result, since the unwelded laps were right on top the layer of bitumen. The welding of these long lines was done toward the outside; the last 400 millimeters from the edge of the bottom, however, were not welded. The irregularities in the bottom resulting from the overlapping are equalized by burning and crimping the bottom sections.



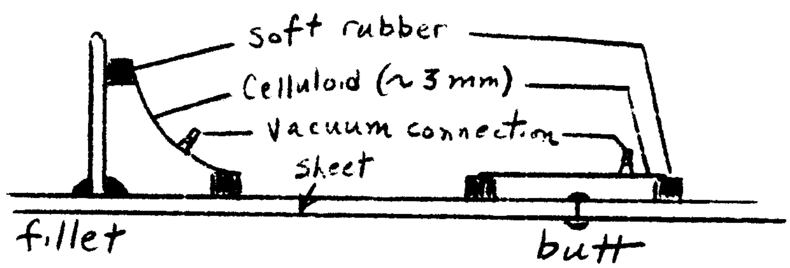

This provides a leveling out for setting on the jacket, and the ends of the bottom can then be welded. As already mentioned, the jacket is welded to the bottom by the step-back-welding method without any ring-iron. To get a satisfactory welding of the bottom, particularly at the crimped places on the outside, the bottom must be set on a cradle. The welding of the first section (course) to the bottom in done by step-back welding simultaneously at four places, the inside fillet welds being done first. Once the first section of the jacket has been set up, the remaining portions of sheet metal are burned off a minimum of about 50 millimeters from the outside of the jacket.

One essential factor for checking the welding work already done, either at the factory or on the construction site, is the type of testing procedure employed. The USSR has either developed, or simply uses, the following testing procedures:

1. x-rays tests
2. vacuum testing
3. magnetographic testing
4. use of isotopes
5. ammonia/phenolphtalein test
6. petroleum test

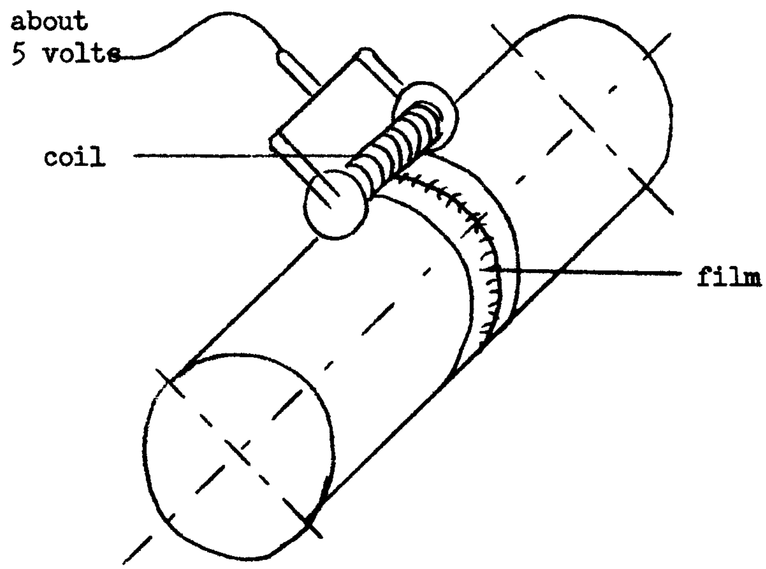
According to the people at the Nefta (Petroleum) Institute, x-ray testing is scarcely ever used any more in the building of these tanks. The method is a good testing procedure, but the rate of 20 meters in 8 hours is too slow.

The vacuum-testing method proved to be especially suitable.




The testing id done by setting a small vacuum chamber about 600-800 millimeters long on the welded seam, after the seam has been wet down with soapy water. After evacuation to about 5,000 mm mercury, any leaks will show up as bubbles, which can be marked off with chalk. These defective places are then erased and welded over. The entire roof and bottom of the tank are tested in this way. The testing rate is about one meter per minute. Even fillet and long-seam welds can be tested by this method, without the trouble of filling the tank with water up to the first section, which is still being done. This method does not require any special training of testing crews.

Another efficient testing method used in the USSR is the magnetographic method of testing welds.




MAGNETIC TESTING WITHOUT RECORDING DEVICE

A strip of film prepared with iron filings is placed over the welded seam, and an induction coil is rolled over the film. The current required is only about six volts (automobile battery). Any voids, slag inclusions, or laminations will cause a disturbance of the field, which will be reproduced on the film. The film is then run on a recorder which projects the disturbance pulses on an oscilloscope. It must be remembered that slag inclusions which are exactly round or voids which are exactly round will be passed by the magnetic lines smoothly, and will not be visible. This means that there is a certain degree of unreliability involved in this method. The testing rate in this case is 300-400 meters per 8 hours for sheets 3-12 mm thick, with two men operating the testing equipment. The equipment, which is not yet available, will cost 800 rubles. The film is produced by Agfa-Wolfen.

Another efficient method of testing weldments is the use of isotopes. This method is jst getting started in the Soviet Union, but alreay is widely used. Use is made primarily of the isotopes: barium, cobalt-60, cesium 134 and 137 (below 4-mm sheet-thicknesses).

Since other testing methods are assumed to be generally well known, no special discussion will be mffered here. (The foreword gives additional information on testing.)

## Protection Against Corrosion

The careful storage of the semifinished products for the manufacture of large tanks has already been mentioned. The prerequisites for corrosion protection begin with the rolling mill's production of sheets with scale-free surfaces; besides the guarantee thereby of a good basis for welding under powder, such a surface also provides a good surface of adhesion for antirust preparations.

Since the bottom is given a coating of antirust when it is rolled up on the welding machine, the danger of corrosion during transport and construction is avoided. The insulating layer also provides protection against moisture.

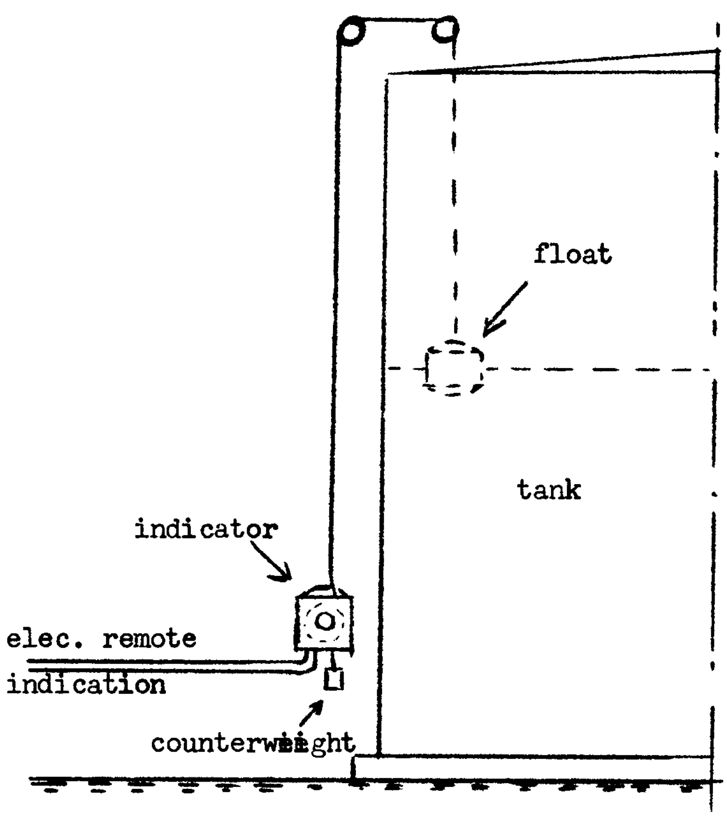
The jacket and the roof supporting members are also coated with antirust at the manufacturing shop. Once the tanks have been set up, they are painted with two coats of aluminum paint on the outside. The piping is wrapped tight and covered with asphalt, and other metal and structural parts are painted in the usual way.

Experience in the Soviet Union has shown that the laying of lines in masonry ducts is the most economical method.

## XIII. Tank-Content Measurement, Ventilation and Circulation

From various visits to tank storage depots in the USSR it was found that the level of contents in tanks is measured by a uniform mechanical method using a float, pulley with perforated band, and indicator at eye-level on the outside of the tank. The indicator is graduated, can have repeater dials for remote checking, and is accurate to within five millimeters (Fig 17).

## MEASURING THE LEVEL OF TANK CONTENTS



A measurement rod is also used to measure tank contents. A certain carelessness in all measurement methods was noticed. Even upon acceptance or approval of the tanks, the contents are ascertained in almost all aases by consulting the papers. Only in special cases is water pumped into the bottom of the tank to provide an exact measurement of the tank contents.

Since the pressures in drop-shaped tanks are essentially higher than in standard tanks, the level is measured with pressure hose, and an appropriate device with a spring valve is used to take samples.

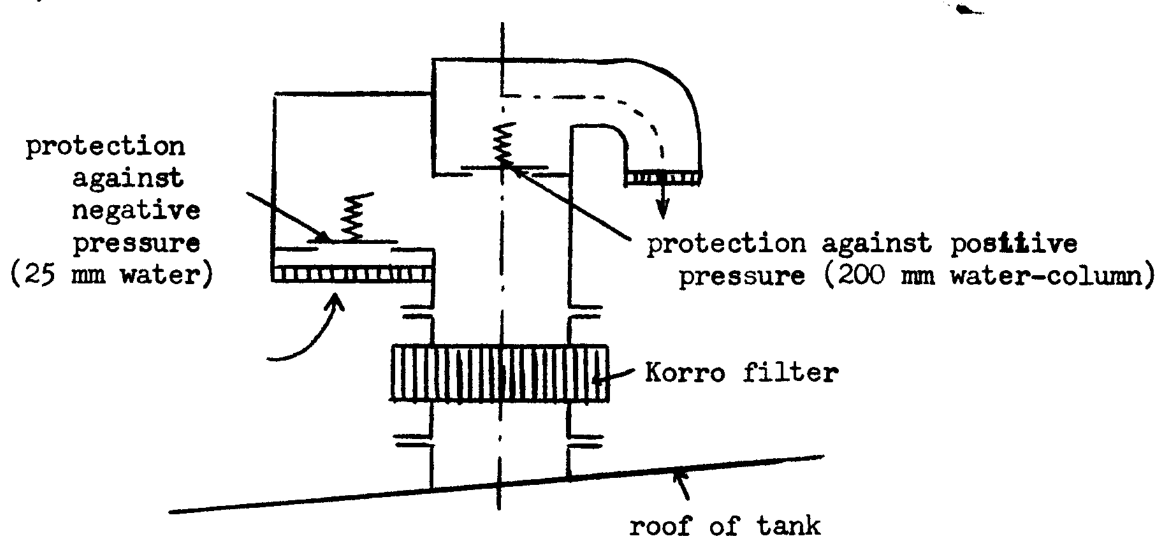
The Soviet Union does not yet make any extensive use of measuring by (pressure) pumping through for any capacities over 600 cubic meters per hour. This is probably due to the good supply of refined hydrocarbons (new discoveries of oil in the Ufa region, larger perhaps even than Baku). There is also no need for mixing large amounts of various diesel fuels for slow-running, high-powered diesel engines. This method is being expanded, however, and the delegation inspected at the Vishins Koy Tank Depot near Moscow an automatic filling device for filling tank trucks using the pressure-flow method of measuring tank content. The entire tank storage installation, which is outside the filling station, is metered by remote indication. A central control panel regulates each individual tank, and a central pumping station supplies light fuel oils to the full-line of the tanks automatically. The filling equipment consists primarily of the meters, controllers, ventilation and drainage devices, plus the filling pipes with power drive and shut-off (explosion-proof).

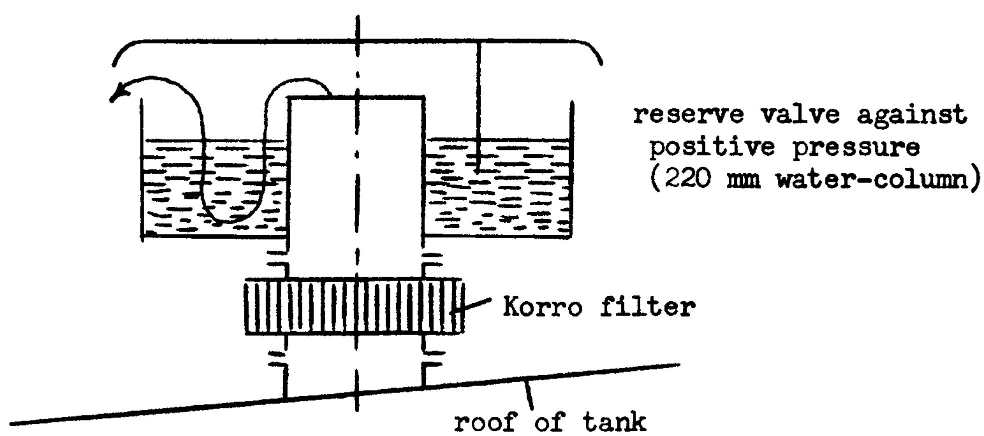
In order to fill his tank truck, the driver gets a key to the pumping installation from the sales office, drives to the pumping installation, inserts the key and starts the mechanism. The setting for the correct amount is made by the sales office, and the operation is monitored via a bridge circuit controller. Once his tank is full, the driver withdraws the key, returns it to the sales office and gets his papers. The only things the driver has to do is to set the pumping installation into operation and put the lid back on his tank feed pipe. This arrangement does away with operating personnel at the pumping station, and even the recording, measuring and monitoring is done efficiently at one central place.

In spite of the rather careless use of light oils and fuels, the Soviets are still trying to solve the problem of the most favorable methods of ventilation and pressure relief, since losses involved here are still considerable. The equipment shown in the attached sketches is now in use. They also use koro-like filters.

The following measures and apparatus have proved effective in cutting down the losses from ventilation and pressure relief:

1. Collecting the gases from several tanks into one tank; the providing of one tank for every 10 storage tanks has been planned.
2. Filling with an inert gas, such as nitrogen; this method is said to be quite economical;
3. The use of floating tanks; and
4. the use of drop-shaped (bulbous) tanks.




PROTECTION AGAINST POSITIVE AND NEGATIVE PRESSURES

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With the use of floating tanks (floating-roof) the venting losses are reduced to 10 percent of the usual losses, but this design is not suitable for larger tanks with capacities of 5,000 - 10,000 cubic meters. The drop-shaped design affords a reduction of venting losses to about 20 percent of the usual losses, but the 25 percent additional material required for such designs (for a 2,000-cubic meter tank) might pay off only over a very long period. Loss figures are given here in the section dealing with the drop-shaped (bulbous) tanks.

## Tank-Construction-Site Equipment and Organization

Only very rarely are single tanks erected in the USSR. In most cases complete tank depots are constructed, requiring considerable operational organization.

The preparation for setting up the tanks is not the laying of foundations, but rather the application of an insulating layer on sandy soil. This saves considerable money otherwise spent on (concrete) foundations.

For erecting a "rolled" sheet-metal tank of 5,000 cubic meter capacity, the erection equipment consists of two caterpillar tractors and two caterpillar cranes for 2 and 7½ tons. These cranes complement one another very well in the assembly operations. Four welding machines are also used (multi-position welding machines are going out of use in the USSR). There are also two (sometimes only one) instrument trucks which hold all the instruments, thus dispensing with the need for the building of shacks to shelter the equipment, or special shipments of instruments.



50X1-HUM

This also saves a lot of time and money, as does the use of the (one) housing truck (trailer?) for the crew to live in. A second housing truck is provided if no facilities are nearby.

For this example 5,000-cubic-meter tank a crew of 10 men is required for installation. The crew is divided into two brigades, one special brigade of four mechanics, who also drive the caterpillar tractors, and a second brigade of welders, four experienced welders and two helpers. This organization is adhered to quite strictly, otherwise the operations are not smooth.

The USSR does not yet employ machines which weld under powder for the work on such assembling of tanks; they are trying to develop a welding machine of this type.

The first operation is rolling out the two sections of the bottom. The middle seam is welded immediately and tested with vacuum. The jacket, which lies next to the site, still rolled up, is set up with an A-shaped (tepee) hoisting rig and the two caterpillar tractors (photo on page 129 of document). The jacket is rolled out with the help of one caterpillar tractor and a special crane. The jacket is welded to the bottom without any annular corner piece.

## Railroad Filling Stations

The filling- and discharging facilities (loading bridges) for railroad tank cars are either steel (for example, ODESSA) or concrete (for example, KUYBYSHEV).

Thes stations fill and unload tank cars, either into pipelines or into channels built between the railroad tracke. The cars have steam jackets which connect to steam hoses at the station.

Generally the piplelines are laid below the frost line in the graund, but at the discharging stations they run under the catwalk of the bridge.

In addition to the steam lines for heating the tank contents, there are water pipes which connect up to fire hoses. The lighting at the stations is explosion-proof.

## Inspection of a Transshipping Station near Moscow on 12 April 1958

Only two products, automobile gasoline and diesel fuel, are transported to this station from a refinery some seven kilometers away. The initial pipeline pressure at the refinery is about 15 kilograms per square centimeter, and about 1½ kilograms per square centimeter at the station. The liquid in the pipelines flows at a rate of about 1½ - 2 meters per second.

The incoming products are stored in tanks and then to tank trucks. The level in the tanks is measured by float attached to a ribbon, a counter and indicator with remote meters. The individual tank contents can be read off first in meters, and then, by throwing a lever, in centimeters; measurement accuracy is $\pm$ 5 %.

When a tank is either full or empty, a visual and a sound signal are activated.

The remote indicators use five volts and 40 milliampers of current; the apparatus are explosion-proof.

Samples are taken from a pipe extending from the top to the bottom of the tank from siphons spaced about one meter apart (syphon material V2A!). A second pipe supplies an air pressure of two kilograms per square meter to the syphons, thus closing the valve. The sample is taken by opening the lower slide.

Pumps and Accessories

The pumphouses of the pipelines use the following type pumps:

500 cubic meters per hour
750 cubic meters per hour
1,100 cubic meters per hour.
(2,200 cubic meters per hour pumps in development stage)

These pumps are designed for pressures of 34, 50 and 64 kg per square centimeter.

For light oils they use only centrifugal pumps driven by explosion-proofed motors; if such motors are not available, the regular motors are housed in shacks apart from the pumphouse.

Stopping boxes are used to seal the hole in the wall for the shaft.

For heavy and crude they use piston or gear pumps, either with electric motors or steam driven. According to local conditions, the pump capacity would then be

110 - 150 - 250 - 300 - 315 - 400 cubic meters per hour.

The capacity of the centrifugal pumps is regulated by adjusting the output valve; the steam-driven pumps are regulated by the amount of steam.

No electric motors with rpm-control are used for pumps.

They consider it better to use a few high-capacity pumps rather than several low-capacity pumps.

The flow velocity in the pipelines is:

about 2.6 meters per second for light oils;

about 1.5 meters per second for heavy oils.

Some of the pumphouses are underground, so that the incoming and outgoing piping can be kept below the frostline. This also keeps the suction lift lower.

Normally, the distribution stations are separated from the pumphouses.

If the distance between the tank depot and the pumphouse is rather small, only one pipeline is used for both light and heavy products; if the distances are great, however, each product often (particularly aircraft gasoline) has its own pipeline.

In winter, the pumphouses are ventilated by fans and venting out the roof.

## Oil heating

Several visits to tank depots and pump stations showed that the heavy oils are heated primarily (almost exclusively) by steam, at temperatures of 20-70 deg C. Wherever possible, already existing local heating facilities (central heating plants) are utilized. The entire oil-handling station for the Odessa oil-dock is serviced by a heating facility about $2\frac{1}{2}$ kilometers away. They reported the steam consumption here as 250 tons per hour, to heat the following facilities primarily:

1. all the buildings
2. pumping station for heavy oils with a turnover of 200 tons in two hours (two tracks for 28 tankcars each, and a second station under construction);
3. all the tank installations and sewage tanks.

The heating temperatures were in the range of 60-70 deg C, which are required for maintaining the rate of product transfer. To unload from tankcars from the shore side, the transshipping (pumping) station has a central steam line with connections (see the Odessa attachment), which also feeds the heating system in the tankcar,,which is either an immersion-type or attached heater. Since the tanks can be heated, the handling of the contents is guaranteed. An interesting thing is that the loading and unloading of ships (tankers) to and from the tank depot (from offshore) is done over a triple pipeline three kilometers long. Inside the harbor, the pipeline runs underfoot, but between the harbor and the tank depot it runs overhead, and is neither heated nor insulated. The ship's own equipment is used to heat oil during unloading from the ship. The temperature drop of the oil from the ship to the depot three kilometers distant was given as 10 - 15 deg C. When the temperature outside is very low, however, a circulating pump (steam-driven, 500 cubic meters per hour) is connected up with the pipeline.

 

A pumping staion for oil pipelines was inspected in the vicinity of KUYBYCHEV. It consisted of a tank depot with about 20 5,000-cubic-meter tanks, a pumping station, boiler room and repair shop, and housing. This station pumps partially refined crude, which arrives through a 500-mm pipeline from a distance of 200 km, into tanks and then pumps it through another pipeline for a distance of 187 km. The latter pumping is done with six-stage centrifugal pumps with two pressure stages, 35 and 67 atmospheres, gauge. The mass flow is thus 350 cubic meters per hour. A central boiler house with four boiler units (each 3 tons of steam per hour) heats the station. The boilers are oil-fired. The pipeline is underground, and the average temperature of the oil in the pipline is given as 7°C. According to the operating personnel, the oil is heated only when the outside temperature drops to 0- -2°C. The installation was well organized and laid out, and quite tidy.

## Safety and Fire-Protection

The USSR takes extensive measures to protect tank depots against fire. Since these are quite large installations, the observance of fire regulations is extremely important. Visits to several installations showed a uniform system of fire-prevention, the general aspects of which are as follows:

1) Fire-prevention: All the depots are laid out as open installations with the various stations well spaced apart and plenty of accessible roads leading to all parts of the depots. At the NOVO-KUYBYCHEV the refinery is laid out in

checkerboard fashion, with extraordinarily generous space allotments for individual installations. Even though this arrangembnt requires more material expenditures for construction, the addéd safety factor more than compensates it. The Novo-Kuybychev refinery has a capacity of ten million tons per year.

There are also sufficient warning signs and regulations posted about the premises, and special fire-prevention and fire-fighting training is provided. In addition, nearly all the piping is underground, and the laying of piping in masonry ducts has proved particularly effective.

2) <u>Fire-fighting</u>: For every 20,000 cubic-meter tank storage, there is a wall surrounding the area; it is $1\frac{1}{2}$ - 2 meters high and about 10 meters from the tank itself. According to regulations, any isolated, single tank has to be suffounded by a wall. Ventilators have fire-proof filters. The foam-laying (layer about 50 centimeters thick) equipment for tanks must supply foam at a rate of 0.7 liter of foam per second per square meter of surface. Foam generators use venturi nozzles (flow-through type) to produce the foam. The additives for extinguishing flames are primarily alkaline substances.

The foam generators must be at least 60 meters from the tanks, in order to provide satisfactory mixing of the extinguishing substance with the water. All the tanks have two risers, with the foam attachment about knee-high at the side of the tank. It is not considered necessary to have a foam-attachment on the outside of the wall surrounding the tank. The double riser provides the distribution of foam under the roof of the tank without a spray attachment. The risers are as follows:

| | | |
|---|---|---|
| 1 double riser: | for tanks up to | 1,000 cubic meters capacity |
| 2 double risers: | for tanks up to | 5,000 cubic meters capacity |
| 3 double risers: | for tanks up to | 10,000 cubic meters capacity. |

Water hydrants are obviously also necessarily inspected regularly to make sure that a supply of water will be available at any time on short notice.

The various pumping stations visited had fire-fighting equipment consisting of foam, sand, and water hydrants spaced about 30-40 meters apart. No foam equipment was seen at the discharging stations, not even at the newly constructed railroad-tank-car-filling stations in Novo-Kuybyshev and Odessa. They put considerable importance there on having open track available at all times in order to be able to uncouple the tank cars in case of fire.

Inside the pumphouse all the electrical equipment, including the motors, are protected against explosion. The usual ventilation equipment was present. At pumphouse which had no explosion-proof motors (procurement difficulties), the motor and drive were separated, and stuffing boxes were used as seals.

No fired locomotives are permitted to enter the tracks. A ready, partially motorized, fire-fighting facility was seen at all the larger installations.

When repairs are required, the oil product is emptied from the tank, the tank is blown through with air, washed with steam or water; then only can repair work begin.

Small repairs, such as calking, are also done when the tank is full. If repairs are done on a tank (to be empties) near several other tanks, then the other tanks must also be emptied before the repair work can begin.

Welding is done under a cloth, always with several fire-fighting personnel on the spot.

Signalling and Remote Communications

The wide-spread, open arrangement of the tank depots and pumping stations requires communications over rather large distances. Even shipping from the dock or from offshore often requires a coordination of several operations which cannot be accomplished with the aid of visible signals. At the Kuybyshev Refinery, the large tank depot at PAVELTROVSKIY and the ODESSA oil dock, the dispatcher system was used primarily. It uses a central station to control all required operations, using:

1. telephone
2. two-way voice radio
3. visual signals.

At Paveltrovskiy the instructions are issued via the dispatcher, which controls two charging-bridges, three pumping stations, the boiler house, the fire-fighting facility, and the central water-pumping station. The radio-telephone stations were in front of the pumping stations and had colored signal lamps for operation at night. Radio-telephone might well be the best means of communication since instructions can be given to all stations in the shortest time. At the

ODESSA oil dock, communications were primarily by telephone, perhaps because of the rather great distance (3 kilometers) between the dock to the oil storage depot. The pump foreman gets his signal from the ship, when she is ready to unload, and relays it by telephone to the central office.

The use of communications thus depends to some extent on the local conditions; in all cases, however, a central control of all operations is attempted.

## Results of the Final Discussion and of the Trip in General

At GLAV-GAS (Main Administration of the Gas Industry) in Moscow the final discussion was held on 28 April 1958. The delegation once more described its impressions of the tour. The cooperation of the Soviet friends made possible a good exchange of information, making the trip a success. Once more a request was made for the forwarding of the following documentation:

1. a standard plan for pumping facility from shore or from offshore;
2. legal regulations for pumping stations;
3. brochures on pumps, giving types, series, pressures and capacities;
4. schematic drawings of oil-tank level-metering equipment with remote indication of level;
5. indices and empirical data on flow velocities of refined oils in pipelines with respect to temperature and viscosity (Engler values).

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The forwarding of this material will be the subject of a special request, sint is is particularly important for the possible procurement of pumps.

A few aspects of measuring pipeline flow speeds over 600 cubic meters per hour were touched upon. They explained that this matter was not a direct requirement, but that they were developing the procedure anyway.

The delegation expressed its thanks for the hospitality and treatment of its hosts and presented a book as a token of its appreciation.

In summary, the results of the trip can be stated as follows:

The introduction of central research and planning offices in the USSR has afforded a considerable clarification of problems, of which the manufacturing plants have been relieved. Very often the process-engineering work and the technology problems are handled by the central planning offices, so that the manufacturing plants need only concern themselves with pure manufacturing matters and efficiency measures. The procedure for erecting tanks from rolled (coiled) sheet-metal sections was worked out by the Nefta Institute in Moscow and, once tests proved successful, was turned over to an assembly organization for continuous erection of tanks by this process.

The following information has been forthcoming as a result of the trip:



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1. The introduction of the "rolled" tanks requires a fundamental clarification by the technical control organizations. These "rolled" tanks were produced in the USSR with considerable saving of materials, particularly for the jacket and the roof, which would have to have a corresponding effect on the life of service of the tanks. The problem of life should thus be considered carefully, if such "rolled" tanks are to be used. No figures were able to be had on the service life of the Soviet tanks of this type.

On the basis of the rational manufacturing process of tank production in the USSR, it is possible to produce partial structures.

2. On the basis of Soviet experience, a check might well be made on whether or to what extent circular foundations can be dispensed with.

3. In building tanks in the 2,000-3,000-cubic-meter size range, material savings can be effected, such as dispensing with the circular angle-iron at the base and lighter construction of both the bottom and the top of the tank.

4. The use of vacuum testing equipment reduces the cost of testing.

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